THE

BOTANIC GARDEN;

A Poem, in Two Parts.

PART I.

CONTAINING

THE ECONOMY OF VEGETATION.

PART II.

THE LOVES OF THE PLANTS.

WITH

Philoſophical Notes.

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BOTANIC GARDEN;

ADVERTISEMENT.

THE general deſign of the following ſheets is to inliſt Imagination under the banner of Science; and to lead her votaries from the looſer analogies, which dreſs out the imagery of poetry, to the ſtricter, ones which form the ratiocination of philoſophy. While their particular deſign is to induce the ingenious to cultivate the knowledge of Botany, by introducing them to the veſtibule of that delightful ſcience, and recommending to their attention the immortal works of the celebrated Swediſh Naturaliſt, LINNEUS.

In the firſt Poem, or Economy of Vegetation, the phyſiology of Plants is delivered; and the operation of the Elements, as far as they may be ſuppoſed to affect the growth of Vegetables. In the ſecond Poem, or Loves of the Plants, the Sexual Syſtem of Linneus is explained, with the remarkable properties of many particular plants.

APOLOGY.



IT may be proper here to apologize for many of the ſubſequent conjectures on ſome articles of natural philoſophy, as not being ſupported by accurate inveſtigation or concluſive experiments. Extravagant theories however in thoſe parts of philoſophy, where our knowledge is yet imperfect, are not without their uſe; as they encourage the execution of laborious experiments, or the inveſtigation of ingenious deductions, to confirm or refute them. And ſince natural objects are allied to each other by many affinities, every kind of theoretic diſtribution of them adds to our knowledge by developing ſome of their analogies.

The Roſicrucian doctrine of Gnomes, Sylphs, Nymphs, and Salamanders, was thought to afford a proper machinery for a Botanic poem; as it is probable, that they were originally the names of hieroglyphic figures repreſenting the elements.

Many of the important operations of Nature were ſhadowed or allegorized in the heathen mythology, as the firſt Cupid ſpringing from the Egg of Night, the marriage of Cupid and Pſyche, the Rape of Proſerpine, the Congreſs of Jupiter and Juno, Death and Reſuſcitation of Adonis, &c. many of which are ingeniouſly explained in the works of Bacon, Vol. V. p. 47. 4th Edit. London, 1778. The

Egyptians were poſſeſſed of many diſcoveries in philoſophy and chemiſtry before the invention of letters; theſe were then expreſſed in hieroglyphic paintings of men and animals; which after the diſcovery of the alphabet were deſcribed and animated by the poets, and became firſt the deities of Egypt, and afterwards of Greece and Rome. Alluſions to thoſe fables were therefore thought proper ornaments to a philoſophical poem, and are occaſionally introduced either as repreſented by the poets, or preſerved on the numerous gems and medallions of antiquity.



TO

THE AUTHOR

OF THE

POEM ON THE LOVES OF THE PLANTS.

BY THE REV. W. B. STEPHENS.

OFT tho' thy genius, D——! amply fraught
With native wealth, explore new worlds of mind;
Whence the bright ores of drofslefs wifdom brought,
Stampt by the Mufe's hand, enrich mankind;

Tho' willing Nature to thy curious eye,
Involved in night, her mazy depths betray;
Till at their fource thy piercing fearch defcry
The ftreams, that bathe with Life our mortal clay;

Tho', boldly foaring in fublimer mood
Through tracklefs fkies on metaphyfic wings,
Thou dareft to fcan the approachlefs Caufe of Good,
And weigh with fteadfaft hand the Sum of Things;

Yet wilt thou, charm'd amid his whiſpering bowers,
Oft with lone ſtep by glittering Derwent ſtray,
Mark his green foliage, count his muſky flowers,
That bluſh or tremble to the riſing ray;

While FANCY, ſeated in her rock-roof'd dell,
Liſtening the ſecrets of the vernal grove,
Breathes ſweeteſt ſtrains to thy ſymphonious ſhell,
And gives new echoes to the throne of Love.

Repton, Nov. 28, 1788.

Argument of the Firſt Canto.



THE Genius of the place invites the Goddeſs of Botany. 1. She deſcends, is received by Spring, and the Elements, 59. Addreſſes the Nymphs of Fire. Star-light Night ſeen in the Camera Obſcura, 81. I. Love created the Univerſe. Chaos explodes. All the Stars revolve. God. 97. II. Shooting Stars. Lightning. Rainbow. Colours of the Morning and Evening Skies. Exterior Atmoſphere of inflammable Air. Twilight. Fire-balls. Aurora Borealis. Planets. Comets. Fixed Stars. Sun's Orb, 115. III. 1. Fires at the Earth's Centre. Animal Incubation, 137. 2. Volcanic Mountains. Venus viſits the Cyclops, 149. IV. Heat confined on the Earth by the Air. Phoſphoric lights in the Evening. Bolognian Stone. Calcined Shells. Memnon's Harp, 173. Ignis fatuus. Luminous Flowers. Glow-worm. Fire-fly. Luminous Sea-inſects. Electric Eel. Eagle armed with Lightning, 189. V. 1. Diſcovery of Fire. Meduſa, 209. 2. The chemical Properties of Fire. Phoſphorus. Lady in Love, 223. 3. Gunpowder, 237. VI. Steam-engine applied to Pumps, Bellows, Water-engines, Corn-mills, Coining, Barges, Waggons, Flying-chariots, 253. Labours of Hercules. Abyla and Calpe, 297. VII. 1. Electric Machine. Heſperian Dragon. Electric kiſs. Halo round the heads of Saints. Electric Shock. Fairy-rings, 335. 2. Death of Profeſſor Richman, 371. 3. Franklin draws Lightning

THE

ECONOMY OF VEGETATION.

CANTO I.

"STAY YOUR RUDE STEPS! whoſe throbbing breaſts infold
The legion-fiends of Glory, or of Gold!
STAY! whoſe falſe lips ſeductive ſimpers part,
While Cunning neſtles in the harlot-heart!—
For you no Dryads dreſs the roſeate bower,
For you no Nymphs their ſparkling vaſes pour;

Unmark'd by you, light Graces ſwim the green,
And hovering Cupids aim their ſhafts, unſeen.

"But THOU! whoſe mind the well-attemper'd ray
Of Taſte and Virtue lights with purer day;
Whoſe finer ſenſe each ſoft vibration owns
With ſweet reſponſive ſympathy of tones;
So the fair flower expands it's lucid form
To meet the ſun, and ſhuts it to the ſtorm;—
For thee my borders nurſe the fragrant wreath,
My fountains murmur, and my zephyrs breathe;
Slow ſlides the painted ſnail, the gilded fly
Smooths his fine down, to charm thy curious eye;
On twinkling fins my pearly nations play,
Or win with ſinuous train their trackleſs way;
My plumy pairs in gay embroidery dreſs'd
Form with ingenious bill the penſile neſt,

So the fair flower. l. 13. It ſeems to have been the original deſign of the philoſophy of Epicurus to render the mind exquiſitely ſenſible to agreeable ſenſations, and equally inſenſible to diſagreeable ones.

To Love's ſweet notes attune the liſtening dell,
And Echo ſounds her ſoft ſymphonious ſhell.

" And, if with Thee ſome hapleſs Maid ſhould ſtray,
Diſaſterous Love companion of her way,
Oh, lead her timid ſteps to yonder glade,
Whoſe arching cliffs depending alders ſhade;
There, as meek Evening wakes her temperate breeze,
And moon-beams glimmer through the trembling trees,
The rills, that gurgle round, ſhall ſoothe her ear,
The weeping rocks ſhall number tear for tear;
There as ſad Philomel, alike forlorn,
Sings to the Night from her accuſtomed thorn;
While at ſweet intervals each falling note
Sighs in the gale, and whiſpers round the grot;

Diſaſterous Love. l. 26. The ſcenery is taken from a botanic garden about a mile from Lichfield, where a cold bath was erected by Sir John Floyer. There is a grotto ſurrounded by projecting rocks, from the edges of which trickles a perpetual ſhower of water; and it is here repreſented as adapted to love-ſcenes, as being thence a proper reſidence for the modern goddeſs of Botany, and the eaſier to introduce the next poem on the Loves of the Plants according to the ſyſtem of Linneus.

The ſiſter-woe ſhall calm her aching breaſt,
And ſofter ſlumbers ſteal her cares to reſt.—

"Winds of the North! reſtrain your icy gales,
Nor chill the boſom of theſe happy vales!
Hence in dark heaps, ye gathering Clouds, revolve!
Diſperſe, ye Lightnings! and, ye Miſts, diſſolve!
—Hither, emerging from yon orient ſkies,
Botanic Goddess! bend thy radiant eyes;
O'er theſe ſoft ſcenes aſſume thy gentle reign,
Pomona, Ceres, Flora in thy train;
O'er the ſtill dawn thy placid ſmile effuſe,
And with thy ſilver ſandals print the dews;
In noon's bright blaze thy vermil veſt unfold,
And wave thy emerald banner ſtar'd with gold."

Thus ſpoke the Genius, as He ſtept along,
And bade theſe lawns to Peace and Truth belong;
Down the ſteep ſlopes He led with modeſt ſkill
The willing pathway, and the truant rill,

Stretch'd o'er the marſhy vale yon willowy mound,
Where ſhines the lake amid the tufted ground,
Raiſed the young woodland, ſmooth'd the wavy green,
And gave to Beauty all the quiet ſcene.—

She comes!—the GODDESS!—through the whiſpering air,
Bright as the morn, deſcends her bluſhing car;
Each circling wheel a wreath of flowers intwines,
And gem'd with flowers the ſilken harneſs ſhines;
The golden bits with flowery ſtuds are deck'd,
And knots of flowers the crimſon reins connect.—
And now on earth the ſilver axle rings,
And the ſhell ſinks upon its ſlender ſprings;
Light from her airy ſeat the Goddeſs bounds,
And ſteps celeſtial preſs the panſied grounds.

Fair Spring advancing calls her feather'd quire,
And tunes to ſofter notes her laughing lyre;
Bids her gay hours on purple pinions move,
And arms her Zephyrs with the ſhafts of Love,

Pleaſed Gnomes, aſcending from their earthy beds,
Play round her graceful footſteps, as ſhe treads;
Gay Sylphs attendant beat the fragrant air
On winnowing wings, and waft her golden hair;
Blue Nymphs emerging leave their ſparkling ſtreams,
And Fiery Forms alight from orient beams;
Muſk'd in the roſe's lap freſh dews they ſhed,
Or breathe celeſtial luſtres round her head.

First the fine Forms her dulcet voice requires,
Which bathe or baſk in elemental fires;
From each bright gem of Day's refulgent car,
From the pale ſphere of every twinkling ſtar,
From each nice pore of ocean, earth, and air,
With eye of flame the ſparkling hoſts repair,

Pleaſed Gnomes. l. 73. The Roſicrucian doctrine of Gnomes, Sylphs, Nymphs, and Salamanders affords proper machinery for a philoſophic poem; as it is probable that they were originally the names of hieroglyphic figures of the Elements, or of Genii preſiding over their operations. The Faries of more modern days ſeem to have been derived from them, and to have inherited their powers. The Gnomes and Sylphs, as being more nearly allied to modern Fairies are repreſented as either male or female, which diſtinguiſhes the latter from the Auræ of the Latin Poets, which were only female; except the winds, as Zephyrus and Auſter, may be ſuppoſed to have been their huſbands.

Mix their gay hues, in changeful circles play,
Like motes, that tenant the meridian ray.—
So the clear Lens collects with magic power
The countleſs glories of the midnight hour;
Stars after ſtars with quivering luſtre fall,
And twinkling glide along the whiten'd wall.—
Pleaſed, as they paſs, ſhe counts the glittering bands,
And ſtills their murmur with her waving hands;
Each liſtening tribe with fond expectance burns,
And now to theſe, and now to thoſe, ſhe turns.

I. "Nymphs of primeval Fire! your veſtal train
Hung with gold-treſſes o'er the vaſt inane,

Nymphs of primeval fire. l. 97. The fluid matter of heat is perhaps the moſt extenſive element in nature; all other bodies are immerſed in it, and are preſerved in their preſent ſtate of ſolidity or fluidity by the attraction of their particles to the matter of heat. Since all known bodies are contractible into leſs ſpace by depriving them of ſome portion of their heat, and as there is no part of nature totally deprived of heat, there is reaſon to believe that the particles of bodies do not touch, but are held towards each other by their ſelf-attraction, and recede from each other by their attraction to the maſs of heat which ſurrounds them; and thus exiſt in an equilibrium between theſe two powers. If more of the matter of heat be applied to them, they recede further from each other, and become fluid; if ſtill more be applied, they take an aerial form, and are termed Gaſſes by the modern chemiſts. Thus when water is heated to a certain degree, it would inſtantly aſſume the form of ſteam, but for the preſſure of the atmoſphere, which prevents this change from taking place ſo eaſily; the ſame is true of

Pierced with your ſilver ſhafts the throne of Night,
And charm'd young Nature's opening eyes with light;
When Love Divine, with brooding wings unfurl'd,
Call'd from the rude abyſs the living world.

quickſilver, diamonds, and of perhaps all other bodies in Nature; they would firſt become fluid, and then aeriform by appropriated degrees of heat. On the contrary, this elaſtic matter of heat, termed Calorique in the new nomenclature of the French Academicians, is liable to become conſolidated itſelf in its combinations with ſome bodies, as perhaps in nitre, and probably in combuſtible bodies as ſulphur and charcoal. See note on l. 232, of this Canto. Modern philoſophers have not yet been able to decide whether light and heat be different fluids, or modifications of the ſame fluid, as they have many properties in common. See note on l. 468 of this Canto.

When Love Divine. l. 101. From having obſerved the gradual evolution of the young animal or plant from its egg or ſeed; and afterwards its ſucceſſive advances to its more perfect ſtate, or maturity; philoſophers of all ages ſeem to have imagined, that the great world itſelf had likewiſe its infancy and its gradual progreſs to maturity; this ſeems to have given origin to the very antient and ſublime allegory of Eros, or Divine Love, producing the world from the egg of Night, as it floated in Chaos. See l. 419. of this Canto.

The external cruſt of the earth, as far as it has been expoſed to our view in mines or mountains, countenances this opinion; ſince theſe have evidently for the moſt part had their origin from the ſhells of fiſhes, the decompoſition of vegetables, and the recrements of other animal materials, and muſt therefore have been formed progreſſively from ſmall beginnings. There are likewiſe ſome apparently uſeleſs or incomplete appendages to plants and animals, which ſeem to ſhew they have gradually undergone changes from their original ſtate; ſuch as the ſtamens without anthers, and ſtyles without ſtigmas of ſeveral plants, as mentioned in the note on Curcuma, Vol. II. of this work. Such as the halteres, or rudiments of wings of ſome two-winged inſects; and the paps of male animals; thus ſwine have four toes, but two of them are imperfectly formed, and not long enough for uſe. The allantoide in ſome animals ſeems to have become extinct; in others is above tenfold the ſize, which would ſeem neceſſary for its purpoſe. Buffon du Cochon. T. 6. p. 257. Perhaps all the ſuppoſed monſtrous births of Nature are remains of their habits of production in their former leſs perfect ſtate, or attempts towards greater perfection.

"—Let there be light!" proclaim'd the Almighty Lord,
Aſtoniſh'd Chaos heard the potent word;—
Through all his realms the kindling Ether runs,
And the maſs ſtarts into a million ſuns;
Earths round each ſun with quick exploſions burſt,
And ſecond planets iſſue from the firſt;

Through all his realms. l. 105. Mr. Herſchel has given a very ſublime and curious account of the conſtruction of the heavens, with his diſcovery of ſome thouſand nebulæ, or clouds of ſtars; many of which are much larger collections of ſtars, than all thoſe put together, which are viſible to our naked eyes, added to thoſe which form the galaxy, or milky zone, which ſurrounds us. He obſerves that in the vicinity of theſe cluſters of ſtars there are proportionally fewer ſtars than in other parts of the heavens; and hence he concludes, that they have attracted each other, on the ſuppoſition that infinite ſpace was at firſt equally ſprinkled with them; as if it had at the beginning been filled with a fluid maſs, which had coagulated. Mr. Herſchel has further ſhewn, that the whole ſidereal ſyſtem is gradually moving round ſome centre, which may be an opake maſs of matter, Philoſ. Tranſ. V. LXXIV. If all theſe Suns are moving round ſome great central body; they muſt have had a projectile force, as well as a centripetal one; and may thence be ſuppoſed to have emerged or been projected from the material, where they were produced. We can have no idea of a natural power, which could project a Sun out of Chaos, except by comparing it to the exploſions or earthquakes owing to the ſudden evolution of aqueous or of other more elaſtic vapours; of the power of which under immeaſurable degrees of heat, and compreſſion, we are yet ignorant.

It may be objected, that if the ſtars had been projected from a Chaos by exploſions, that they muſt have returned again into it from the known laws of gravitation; this however would not happen, if the whole of Chaos, like grains of gunpowder, was exploded at the ſame time, and diſperſed through infinite ſpace at once, or in quick ſucceſſion, in every poſſible direction. The ſame objection may be ſtated againſt the poſſibility of the planets having been thrown from the ſun by exploſions; and the ſecondary planets from the primary ones; which will be ſpoken of more at large in the ſecond Canto, but if the planets are ſuppoſed to have been projected from their ſuns, and the ſecondary from the

Bend, as they journey with projectile force,
In bright ellipſes their reluctant courſe;
Orbs wheel in orbs, round centres centres roll,
And form, ſelf-balanced, one revolving Whole.
—Onward they move amid their bright abode,
Space without bound, THE BOSOM OF THEIR GOD!

II. "ETHEREAL POWERS! YOU chaſe the ſhooting ſtars,
Or yoke the vollied lightenings to your cars,
Cling round the aërial bow with priſms bright,
And pleaſed untwiſt the ſevenfold threads of light;

primary ones, at the beginning of their courſe; they might be ſo influenced or diverted by the attractions of the ſuns, or ſun, in their vicinity, as to prevent their tendency to return into the body, from which they were projected.

If theſe innumerable and immenſe ſuns thus riſing out of Chaos are ſuppoſed to have thrown out their attendant planets by new exploſions, as they aſcended; and thoſe their reſpective ſatellites, filling in a moment the immenſity of ſpace with light and motion, a grander idea cannot be conceived by the mind of man.

Chaſe the ſhooting ſtars. l. 115. The meteors called ſhooting ſtars, the lightening, the rainbow, and the clouds, are phenomena of the lower regions of the atmoſphere. The twilight, the meteors call'd fire-balls, or flying dragons, and the northern lights, inhabit the higher regions of the atmoſphere. See additional notes, No. I.

Cling round the aerial bow. l. 117. See additional notes, No. II

Eve's ſilken couch with gorgeous tints adorn,
And fire the arrowy throne of riſing Morn.
—Or, plum'd with flame, in gay battalion's ſpring
To brighter regions borne on broader wing;
Where lighter gaſes, circumfuſed on high,
Form the vaſt concave of exterior ſky;

Eve's ſilken couch. l. 119. See additional notes, No. III.

Where lighter gaſes. l. 123. Mr. Cavendiſh has ſhewn, that the gas called inflammable air, is at leaſt ten times lighter than common air; Mr. Lavoiſier contends, that it is one of the component parts of water, and is by him called hydrogene. It is ſuppoſed to afford their principal nouriſhment to vegetables and thence to animals, and is perpetually riſing from their decompoſition; this ſource of it in hot climates, and in ſummer months, is ſo great as to exceed eſtimation. Now if this light gas paſſes through the atmoſphere, without combining with it, it muſt compoſe another atmoſphere over the aerial one; which muſt expand, when the preſſure above it is thus taken away, to inconceivable tenuity.

If this ſupernatural gaſſeous atmoſphere floats upon the aerial one, like ether upon water, what muſt happen? 1. it will flow from the line, where it will be produced in the greateſt quantities, and become much accumulated over the poles of the earth; 2. the common air, or lower ſtratum of the atmoſphere, will be much thinner over the poles than at the line; becauſe if a glaſs globe be filled with oil and water, and whirled upon its axis, the centrifugal power will carry the heavier fluid to the circumference, and the lighter will in conſequence be found round the axis. 3. There may be a place at ſome certain latitude between the poles and the line on each ſide the equator, where the inflammable ſupernatant atmoſphere may end, owing to the greater centrifugal force of the heavier aerial atmoſphere. 4. Between the termination of the aerial and the beginning of the gaſſeous atmoſphere, the airs will occaſionally be intermixed, and thus become inflammable by the electric ſpark; theſe circumſtances will aſſiſt in explaining the phenomena of fire-balls, northern lights, and of ſome variable winds, and long continued rains.

Since the above note was firſt written, Mr. Volta I am informed has applied the ſuppoſition of a ſupernatant atmoſphere of inflammable air, to explain ſome phenomena in

With airy lens the ſcatter'd rays aſſault,
And bend the twilight round the duſky vault;
Ride, with broad eye and ſcintillating hair,
The rapid Fire-ball through the midnight air;
Dart from the North on pale electric ſtreams,
Fringing Night's ſable robe with tranſient beams.
—Or rein the Planets in their ſwift careers,
Gilding with borrow'd light their twinkling ſpheres;
Alarm with comet-blaze the ſapphire plain,
The wan ſtars glimmering through its ſilver train;

meteorology. And Mr. Lavoiſier has announced his deſign to write on this ſubject. Traitè de Chimie, Tom. I. I am happy to find theſe opinions ſupported by ſuch reſpectable authority.

And bend the twilight. l. 126. The crepuſcular atmoſphere, or the region where the light of the ſun ceaſes to be refracted to us, is eſtimated by philoſophers to be between 40 and 50 miles high, at which time the ſun is about 18 degrees below the horizon; and the rarity of the air is ſuppoſed to be from 4,000 to 10,000 times greater than at the ſurface of the earth. Cotes's Hydroſt. p. 123. The duration of twilight differs in different ſeaſons and in different latitudes; in England the ſhorteſt twilight is about the beginning of October and of March; in more northern latitudes, where the ſun never ſinks more than 18 degrees below the horizon, the twilight continues the whole night. The time of its duration may alſo be occaſionally affected by the varying height of the atmoſphere. A number of obſervations on the duration of twilight in different latitudes might afford conſiderable information concerning the aerial ſtrata in the higher regions of the atmoſphere, and might aſſiſt in determining whether an exterior atmoſphere of inflammable gas, or Hydrogene, exiſts over the aerial one.

Alarm with Comet-blaze. l. 133. See additional notes, No. IV.

Gem the bright Zodiac, ſtud the glowing pole,
Or give the Sun's phlogiſtic orb to roll.

III. Nymphs! your fine forms with ſteps impaſſive mock
Earth's vaulted roofs of adamantine rock;
Round her ſtill centre tread the burning ſoil,
And watch the billowy Lavas, as they boil;
Where, in baſaltic caves impriſon'd deep,
Reluctant fires in dread ſuſpenſion ſleep;
Or ſphere on ſphere in widening waves expand,
And glad with genial warmth the incumbent land.
So when the Mother-bird ſelects their food
With curious bill, and feeds her callow brood;

The Sun's phlogiſtic orb. l. 136. See additional notes, No. V.

Round the ſtill centre. l. 139. Many philoſophers have believed that the central parts of the earth conſiſt of a fluid maſs of burning lava, which they have called a ſubterraneous ſun; and have ſuppoſed, that it contributes to the production of metals, and to the growth of vegetables. See additional notes, No. VI.

Or ſphere on ſphere. l. 143. See additional notes, No. VII.

Warmth from her tender heart eternal ſprings,
And pleaſed ſhe claſps them with extended wings.

"You from deep cauldrons and unmeaſured caves
Blow flaming airs, or pour vitreſcent waves;
O'er ſhining oceans ray volcanic light,
Or hurl innocuous embers to the night.—
While with loud ſhouts to Etna Heccla calls,
And Andes anſwers from his beacon'd walls;

Hurl innocuous embers. l. 152. The immediate cauſe of volcanic eruptions is believed to be owing to the water of the ſea, or from lakes, or inundations, finding itſelf a paſſage into the ſubterraneous fires, which may lie at great depths. This muſt firſt produce by its coldneſs a condenſation of the vapour there exiſting, or a vacuum, and thus occaſion parts of the earth's cruſt or ſhell to be forced down by the preſſure of the incumbent atmoſphere. Afterwards the water being ſuddenly raiſed into ſteam produces all the exploſive effects of earthquakes. And by new acceſſions of water during the intervals of the exploſions the repetition of the ſhocks is cauſed. Theſe circumſtances were hourly illuſtrated by the fountains of boiling water in Iceland, in which the ſurface of the water in the boiling wells ſunk down low before every new ebullition.

Beſides theſe eruptions occaſioned by the ſteam of water, there ſeems to be a perpetual effuſion of other vapours, more noxious and (as far as it is yet known) perhaps greatly more expanſile than water from the Volcanos in various parts of the world. As theſe Volcanos are ſuppoſed to be ſpiracula or breathing holes to the great ſubterraneous fires, it is probable that the eſcape of elaſtic vapours from them is the cauſe, that the earthquakes of modern days are of ſuch ſmall extent compared to thoſe of antient times, of which veſtiges remain in every part of the world, and on this account may be ſaid not be innocuous, but uſeful.

Sea-wilder'd crews the mountain-ſtars admire,
And Beauty beams amid tremendous fire.

" Thus when of old, as myſtic bards preſume,
Huge CYCLOPS dwelt in Etna's rocky womb,
On thundering anvils rung their loud alarms,
And leagued with VUCLAN forged immortal arms;
Deſcending VENUS ſought the dark abode,
And ſooth'd the labours of the griſly God.—
While frowning Loves the threatening falchion wield,
And tittering Graces peep behind the ſhield,
With jointed mail their fairy limbs o'erwhelm,
Or nod with pauſing ſtep the plumed helm;
With radiant eye She view'd the boiling ore,
Heard undiſmay'd the breathing bellows roar,
Admired their ſinewy arms, and ſhoulders bare,
And ponderous hammers lifted high in air,
With ſmiles celeſtial bleſs'd their dazzled ſight,
And Beauty blazed amid infernal night.

IV. "EFFULGENT MAIDS! YOU round deciduous day,
Treſſed with ſoft beams, your glittering bands array;
On Earth's cold boſom, as the Sun retires,
Confine with folds of air the lingering fires;
O'er Eve's pale forms diffuſe phoſphoric light,
And deck with lambent flames the ſhrine of Night.

Confine with folds of air. l. 174. The air, like all other bad conductors of electricity, is known to be a bad conductor of heat; and thence prevents the heat acquired from the ſun's rays by the earth's ſurface from being ſo ſoon diſſipated, in the ſame manner as a blanket, which may be conſidered as a ſponge filled with air, prevents the eſcape of heat from the perſon wrapped in it. This ſeems to be one cauſe of the great degree of cold on the tops of mountains, where the rarity of the air is greater, and it therefore becomes a better conductor both of heat and electricity. See note on Barometz, Vol. II. of this work.

There is however another cauſe to which the great coldneſs of mountains and of the higher regions of the atmoſphere is more immediately to be aſcribed, explained by Dr. Darwin in the Philoſ. Tranſ. Vol. LXXVIII. who has there proved by experiments with the air-gun and air-pump, that when any portion of the atmoſphere becomes mechanically expanded, it abſorbs heat from the bodies in its vicinity. And as the air which creeps along the plains, expands itſelf by a part of the preſſure being taken off when it aſcends the ſides of mountains; it at the ſame time attracts heat from the ſummits of thoſe mountains, or other bodies which happen to be immerſed in it, and thus produces cold. Hence he concludes that the hot air at the bottom of the Andes becomes temperate by its own rarefaction when it aſcends to the city of Quito; and by its further rarefaction becomes cooled to the freezing point when it aſcends to the ſnowy regions on the ſummits of thoſe mountains. To this alſo he attributes the great degree of cold experienced by the aeronauts in their balloons; and which produces hail in ſummer at the height of only two or three miles in the atmoſphere.

Diffuſe phoſphoric light. l. 177. I have often been induced to believe from obſervation, that the twilight of the evenings is lighter than that of the mornings at the ſame diſtance

So, warm'd and kindled by meridian ſkies,
And view'd in darkneſs with dilated eyes,
Bologna's chalks with faint ignition blaze,
Beccari's ſhells emit priſmatic rays.

from noon. Some may aſcribe this to the greater height of the atmoſphere in the evenings having been rarefied by the ſun during the day; but as its denſity muſt at the ſame time be diminiſhed, its power of refraction would continue the ſame. I ſhould rather ſuppoſe that it may be owing to the phoſphoreſcent quality (as it is called) of almoſt all bodies; that is, when they have been expoſed to the ſun they continue to emit light for a conſiderable time afterwards. This is generally believed to ariſe either from ſuch bodies giving out the light which they had previouſly abſorbed; or to the continuance of a ſlow combuſtion which the light they had been previouſly expoſed to had excited. See the next note.

Beccari's ſhells. l. 182. Beccari made made many curious experiments on the phoſphoric light, as it is called, which becomes viſible on bodies brought into a dark room, after having been previouſly expoſed to the ſunſhine. It appears from theſe experiments, that almoſt all inflammable bodies poſſeſs this quality in a greater or leſs degree; white paper or linen thus examined after having been expoſed to the ſunſhine, is luminous to an extraordinary degree; and if a perſon ſhut up in a dark room, puts one of his hands out into the ſun's light for a ſhort time and then retracts it, he will be able to ſee that hand diſtinctly, and not the other. Theſe experiments ſeem to countenance the idea of light being abſorbed and again emitted from bodies when they are removed into darkneſs. But Beccari further pretended, that ſome calcareous compoſitions when expoſed to red, yellow, or blue light, through coloured glaſſes, would on their being brought into a dark room emit coloured lights. This miſtaken fact of Beccari's, Mr. Wilſon decidedly refutes; and among many other curious experiments diſcovered, that if oyſter-ſhells were thrown into a common fire and calcined for about half an hour, and then brought to a perſon who had previouſly been ſome minutes in a dark room, that many of them would exhibit beautiful iriſes of priſmatic colours, from whence probably aroſe Beccari's miſtake. Mr. Wilſon from hence contends, that theſe kinds of phoſphori do not emit the light they had previouſly received, but that they are ſet on fire by the ſun's rays, and continue for ſome time a ſlow combuſtion after they are withdrawn from the light. Wilſon's Experiments on Phoſphori. Dodſley, 1775.

The Bolognian ſtone is a ſelenite, or gypſum, and has been long celebrated for its phoſphoreſcent quality after having been burnt in a ſulphurous fire; and expoſed when

So to the ſacred Sun in Memnon's fane,
Spontaneous concords quired the matin ſtrain;
—Touch'd by his orient beam, reſponſive rings
The living lyre, and vibrates all it's ſtrings;
Accordant ailes the tender tones prolong,
And holy echoes ſwell the adoring ſong.

"You with light Gas the lamps nocturnal feed,
Which dance and glimmer o'er the marſhy mead;

cold to the ſun's light. It may be thus well imitated: Calcine oyſter-ſhells half an hour, pulverize them when cold, and add one third part of flowers of ſulphur, preſs them cloſe into a ſmall crucible, and calcine them for an hour or longer, and keep the powder in a phial cloſe ſtopped. A part of this powder is to be expoſed for a minute or two to the ſunbeams, and then brought into a dark room. The calcined Bolognian ſtone becomes a calcareous hepar of ſulphur; but the calcined ſhells, as they contain the animal acid, may alſo contain ſome of the phoſphorus of Kunkel.

In Memnon's fane. l. 183. See additional notes. No. VIII.

The lamps nocturnal. l. 189. The ignis fatuus or Jack a lantern, ſo frequently alluded to by poets, is ſuppoſed to originate from the inflammable air, or Hydrogene, given up from moraſſes; which being of a heavier kind from its impurity than that obtained from iron and water, hovers near the ſurface of the earth, and uniting with common air gives out light by its ſlow ignition. Perhaps ſuch lights have no exiſtence, and the reflection of a ſtar on watery ground may have deceived the travellers, who have been ſaid to be bewildered by them? if the fact was eſtabliſhed it would much contribute to explain the phenomena of northern lights. I have travelled much in the night, in all ſeaſons of the year, and over all kinds of ſoil, but never ſaw one of theſe Will o'wiſps.

Shine round Calendula at twilight hours,
And tip with ſilver all her ſaffron flowers;
Warm on her moſſy couch the radiant Worm,
Guard from cold dews her love-illumin'd form,
From leaf to leaf conduct the virgin light,
Star of the earth, and diamond of the night.
You bid in air the tropic Beetle burn,
And fill with golden flame his winged urn;
Or gild the ſurge with inſect-ſparks, that ſwarm
Round the bright oar, the kindling prow alarm;
Or arm in waves, electric in his ire,
The dread Gymnotus with ethereal fire.—
Onward his courſe with waving tail he helms,
And mimic lightenings ſcare the watery realms,

Shine round Calendula. l. 191. See note on Tropæolum in Vol. II.

The radiant Worm. l. 193. See additional notes, No. IX.

The dread Gymnotus. l. 202. The Gymnotus electricus is a native of the river of Surinam in South America; thoſe which were brought over to England about eight years ago were about three or four feet long, and gave an electric ſhock (as I experienced) by putting one finger on the back near its head, and another of the oppoſite hand into the water near its tail. In their native country they are ſaid to exceed twenty feet in length,

So, when with briſtling plumes the Bird of JOVE
Vindictive leaves the argent fields above,

and kill any man who approaches them in an hoſtile manner. It is not only to eſcape its enemies that this ſurprizing power of the fiſh is uſed, but alſo to take its prey; which it does by benumbing them and then devouring them before they have time to recover, or by perfectly killing them; for the quantity of the power ſeemed to be determined by the will or anger of the animal; as it ſometimes ſtruck a fiſh twice before it was ſufficiently benumbed to be eaſily ſwallowed.

The organs productive of this wonderful accumulation of electric matter have been accurately diſſected and deſcribed by Mr. J. Hunter. Philoſ. Tranſ. Vol. LXV. And are ſo divided by membranes as to compoſe a very extenſive ſurface, and are ſupplied with many pairs of nerves larger than any other nerves of the body; but how ſo large a quantity is ſo quickly accumulated as to produce ſuch amazing effects in a fluid ill adapted for the purpoſe is not yet ſatisfactorily explained. The Torpedo poſſeſſes a ſimilar power in a leſs degree, as was ſhewn by Mr. Walch, and another fiſh lately deſcribed by Mr. Paterſon. Philo. Tranſ. Vol. LXXVI.

In the conſtruction of the Leyden-Phial, (as it is called) which is coated on both ſides, it is known, that above one hundred times the quantity of poſitive electricity can be condenſed on every ſquare inch of the coating on one ſide, than could have been accumulated on the ſame ſurface if there had been no oppoſite coating communicating with the earth; becauſe the negative electricity, or that part of it which cauſed its expanſion, is now drawn off through the glaſs. It is alſo well known, that the thinner the glaſs is (which is thus coated on both ſides ſo as to make a Leyden-phial, or plate) the more electricity can be condenſed on one of its ſurfaces, till it becomes ſo thin as to break, and thence diſcharge itſelf.

Now it is poſſible, that the quantity of electricity condenſible on one ſide of a coated phial may increaſe in ſome high ratio in reſpect to the thinneſs of the glaſs, ſince the power of attraction is known to decreaſe as the ſquares of the diſtances, to which this circumſtance of electricity ſeems to bear ſome analogy. Hence if an animal membrane, as thin as the ſilk-worm ſpins its ſilk, could be ſo ſituated as to be charged like the Leyden bottle, without burſting, (as ſuch thin glaſs would be liable to do,) it would be difficult to calculate the immenſe quantity of electric fluid, which might be accumulated on its ſurface. No land animals are yet diſcovered which poſſeſs this power, though the air would have been a much better medium for producing its effects; perhaps the ſize of the neceſſary apparatus would have been inconvenient to land animals.

Borne on broad wings the guilty world he awes,
And graſps the lightening in his ſhining claws.

V. 1. "NYMPHS! YOUR ſoft ſmiles uncultur'd man ſubdued,
And charm'd the Savage from his native wood;
YOU, while amazed his hurrying Hords retire
From the fell havoc of devouring FIRE,

In his ſhining claws. l. 208. Alluding to an antique gem in the collection of the Grand Duke of Florence. Spence.

Of devouring fire. l. 212. The firſt and moſt important diſcovery of mankind ſeems to have been that of fire. For many ages it is probable fire was eſteemed a dangerous enemy, known only by its dreadful devaſtations; and that many lives muſt have been loſt, and many dangerous burns and wounds muſt have afflicted thoſe who firſt dared to ſubject it to the uſes of life. It is ſaid that the tall monkies of Borneo and Sumatra lie down with pleaſure ruond any accidental fire in their woods; and are arrived to that degree of reaſon, that knowledge of cauſation, that they thruſt into the remaining fire the half-burnt ends of the branches to prevent its going out. One of the nobles of the cultivated people of Otaheita, when Captain Cook treated them with tea, catched the boiling water in his hand from the cock of the tea-urn, and bellowed with pain, not conceiving that water could become hot, like red fire.

Tools of ſteel conſtitute another important diſcovery in conſequence of fire; and contributed perhaps principally to give the European nations ſo great ſuperiority over the American world. By theſe two agents, fire and tools of ſteel, mankind became able to cope with the vegetable kingdom, and conquer provinces of foreſts, which in uncultivated countries almoſt exclude the growth of other vegetables, and of thoſe animals which are neceſſary to our exiſtence. Add to this, that the quantity of our food is alſo increaſed by the uſe of fire, for ſome vegetables become ſalutary food by means of the heat uſed in cookery, which are naturally either noxious or difficult of digeſtion; as

Taught, the firſt Art! with piny rods to raiſe
By quick attrition the domeſtic blaze,
Fan with ſoft breath, with kindling leaves provide,
And lift the dread Deſtroyer on his ſide.
So, with bright wreath of ſerpent-treſſes crown'd,
Severe in beauty, young MEDUSA frown'd;
Erewhile ſubdued, round WISDOM'S Ægis roll'd
Hiſs'd the dread ſnakes, and flam'd in burniſh'd gold;
Flaſh'd on her brandiſh'd arm the immortal ſhield,
And Terror lighten'd o'er the dazzled field.

2. NYMPHS! YOU disjoin, unite, condenſe, expand,
And give new wonders to the Chemiſt's hand;

potatoes, kidney-beans, onions, cabbages. The caſſava when made into bread, is perhaps rendered mild by the heat it undergoes, more than by expreſſing its ſuperfluous juice. The roots of white bryony and of arum, I am informed loſe much of their acrimony by boiling.

Young Meduſa frowned. l. 218. The Egyptian Meduſa is repreſented on antient gems with wings on her head, ſnaky hair, and a beautiful countenance, which appears intenſely thinking; and was ſuppoſed to repreſent divine wiſdom. The Grecian Meduſa, on Minerva's ſhield, as appears on other gems, has a countenance diſtorted with rage or pain, and is ſuppoſed to repreſent divine vengeance. This Meduſa was one of the Gorgons, at firſt very beautiful and terrible to her enemies; Minerva turned her hair into ſnakes, and Perſeus having cut off her head fixed it on the ſhield of that goddeſs; the ſight of which then petrified the beholders. Dannet. Dict.

On tepid clouds of riſing ſteam aſpire,
Or fix in ſulphur all it's ſolid fire;
With boundleſs ſpring elaſtic airs unfold,
Or fill the fine vacuities of gold;
With ſudden flaſh vitreſcent ſparks reveal,
Or fierce colliſion from the flint and ſteel;

Or fix in ſulphur. l. 226. The phenomena of chemical exploſions cannot be accounted for without the ſuppoſition, that ſome of the bodies employed contain concentrated or ſolid heat combined with them, to which the French Chemiſts have given the name of Calorique. When air is expanded in the air-pump, or water evaporated into ſteam, they drink up or abſorb a great quantity of heat; from this analogy, when gunpowder is exploded it ought to abſorb much heat, that is, in popular language, it ought to produce a great quantity of cold. When vital air is united with phlogiſtic matter in reſpiration, which ſeems to be a ſlow combuſtion, its volume is leſſened; the carbonic acid, and perhaps phoſphoric acid are produced; and heat is given out; which according to the experiments of Dr. Crawford would ſeem to be depoſited from the vital air. But as the vital air in nitrous acid is condenſed from a light elaſtic gas to that of a heavy fluid, it muſt poſſeſs leſs heat than before. And hence a great part of the heat, which is given out in firing gunpowder, I ſhould ſuppoſe, muſt reſide in the ſulphur or charcoal.

Mr. Lavoiſier has ſhewn, that vital air, or Oxygene, looſes leſs of its heat when it becomes one of the component parts of nitrous acid, than in any other of its combinations; and is hence capable of giving out a great quantity of heat in the exploſion of gunpowder; but as there ſeems to be great analogy between the matter of heat, or Calorique, and the electric matter; and as the worſt conductors of electricity are believed to contain the greateſt quantity of that fluid; there is reaſon to ſuſpect that the worſt conductors of heat may contain the moſt of that fluid; as ſulphur, wax, ſilk, air, glaſs. See note on l. 174 of this Canto.

Vitreſcent ſparks. l. 229. When flints are ſtruck againſt other flints they have the property of giving ſparks of light; but it it ſeems to be an internal light, perhaps of electric origin, very different from the ignited ſparks which are ſtruck from flint and ſteel. The ſparks produced by the colliſion of ſteel with flint appear to be globular particles of

Or mark with ſhining letters KUNKEL's name
In the pale Phoſphor's ſelf-conſuming flame.
So the chaſte heart of ſome enchanted Maid
Shines with inſidious light, by Love betray'd;
Round her pale boſom plays the young Deſire,
And ſlow ſhe waſtes by ſelf-conſuming fire.

3. "YOU taught myſterious BACON to explore
Metallic veins, and part the droſs from ore;
With ſylvan coal in whirling mills combine
The cryſtal'd nitre, and the ſulphurous mine;
Through wiry nets the black diffuſion ſtrain,
And cloſe an airy ocean in a grain.—

iron, which have been fuſed, and imperfectly ſcorified or vitrified. They are kindled by the heat produced by the colliſion; but their vivid light, and their fuſion and vitrification are the effects of a combuſtion continued in theſe particles during their paſſage through the air. This opinion is confirmed by an experiment of Mr. Hawkſbee, who found that theſe ſparks could not be produced in the exhauſted receiver. See Keir's Chemical Dict. art. Iron, and art. Earth vitrifiable.

The pale Phoſphor. l. 232. See additionable notes, No. X.

And cloſe an airy ocean. l. 242. Gunpowder is plainly deſcribed in the works of Roger Bacon before the year 1267. He deſcribes it in a curious manner, mentioning

Pent in dark chambers of cylindric braſs,
Slumbers in grim repoſe the ſooty maſs;
Lit by the brilliant ſpark, from grain to grain
Runs the quick fire along the kindling train;
On the pain'd ear-drum burſts the ſudden craſh,
Starts the red flame, and Death purſues the flaſh.

the ſulphur and nitre, but conceals the charcoal in an anagram. The words are, ſed tamen ſalis petræ *lure mope can ubre*, et ſulphuris; et ſic facies tonitrum, et corruſcationem, ſi ſcias, artificium. The words lure mope can ubre are an anagram of carbonum pulvere. Biograph. Britan. Vol. I. Bacon de Secretis Operibus, Cap. XI. He adds, that he thinks by an artifice of this kind Gideon defeated the Midianites with only three hundred men. Judges, Chap. VII. Chamb. Dict. art. Gunpowder. As Bacon does not claim this as his own invention, it is thought by many to have been of much more antient diſcovery.

The permanently elaſtic fluid generated in the firing of gunpowder is calculated by Mr. Robins to be about 244 if the bulk of the powder be 1. And that the heat generated at the time of the exploſion occaſions the rarefied air thus produced to occupy about 1000 times the ſpace of the gunpowder. This preſſure may therefore be called equal to 1000 atmoſpheres or ſix tons upon a ſquare inch. As the ſuddenneſs of this exploſion muſt contribute much to its power, it would ſeem that the chamber of powder, to produce its greateſt effect, ſhould be lighted in the centre of it; which I believe is not attended to in the manufacture of muſkets or piſtols.

From the cheapneſs with which a very powerful gunpowder is likely ſoon to be manufactured from aerated marine acid, or from a new method of forming nitrous acid by means of mangoneſe or other calciform ores, it may probably in time be applied to move machinery, and ſuperſede the uſe of ſteam.

There is a bitter invective in Don Quixot againſt the inventors of gun-powder, as it levels the ſtrong with the weak, the knight caſed in ſteel with the naked ſhepherd, thoſe who have been trained to the ſword, with thoſe who are totally unſkilful in the uſe of it; and throws down all the ſplendid diſtinctions of mankind. Theſe very reaſons ought to have been urged to ſhew that the diſcovery of gunpowder has been of public utiliy by weakening the tyranny of the few over the many.

Fear's feeble hand directs the fiery darts,
And Strength and Courage yield to chemic arts;
Guilt with pale brow the mimic thunder owns,
And Tyrants tremble on their blood-ſtain'd thrones.

VI. NYMPHS! YOU erewhile on ſimmering cauldrons play'd,
And call'd delighted SAVERY to your aid;

Delighted Savery. l. 254. The invention of the ſteam-engine for raiſing water by the preſſure of the air in conſequence of the condenſation of ſteam, is properly aſcribed to Capt. Savery; a plate and deſcription of this machine is given in Harris's Lexicon Technicum, art. Engine. Though the Marquis of Worceſter in his Century of Inventions printed in the year 1663 had deſcribed an engine for raiſing water by the exploſive power of ſteam long before Savery's. Mr. Deſegulier affirms, that Savery bought up all he could procure of the books of the Marquis of Worceſter, and deſtroyed them, profeſſing himſelf then to have diſcovered the power of ſteam by accident, which ſeems to have been an unfounded ſlander. Savery applied it to the raiſing of water to ſupply houſes and gardens, but could not accompliſh the draining of mines by it. Which was afterwards done by Mr. Newcomen and Mr. John Cowley at Dartmouth, in the year 1712, who added the piſton.

A few years ago Mr. Watt of Glaſgow much improved this machine, and with Mr. Boulton of Birmingham has applied it to variety of purpoſes, ſuch as raiſing water from mines, blowing bellows to fuſe the ore, ſupplying towns with water, grinding corn and many other purpoſes. There is reaſon to believe it may in time be applied to the rowing of barges, and the moving of carriages along the road. As the ſpecific levity of air is too great for the ſupport of great burthens by balloons, there ſeems no probable method of flying conveniently but by the power of ſteam, or ſome other exploſive material; which another half century may probable diſcover. See additional notes, No. XI.

Bade round the youth exploſive STEAM aſpire
In gathering clouds, and wing'd the wave with fire;
Bade with cold ſtreams the quick expanſion ſtop,
And ſunk the immenſe of vapour to a drop.—
Preſs'd by the ponderous air the Piſton falls
Reſiſtleſs, ſliding through it's iron walls;
Quick moves the balanced beam, of giant-birth,
Wields his large limbs, and nodding ſhakes the earth.

"The Giant-Power from earth's remoteſt caves
Lifts with ſtrong arm her dark reluctant waves;
Each cavern'd rock, and hidden den explores,
Drags her dark coals, and digs her ſhining ores.—
Next, in cloſe cells of ribbed oak confined,
Gale after gale, He crowds the ſtruggling wind;
The impriſon'd ſtorms through brazen noſtrils roar,
Fan the white flame, and fuſe the ſparkling ore.
Here high in air the riſing ſtream He pours
To clay-built ciſterns, or to lead-lined towers;

Freſh through a thouſand pipes the wave diſtils,
And thirſty cities drink the exuberant rills.—
There the vaſt mill-ſtone with inebriate whirl
On trembling floors his forceful fingers twirl.
Whoſe flinty teeth the golden harveſts grind,
Feaſt without blood! and nouriſh human-kind.

"Now his hard hands on Mona's rifted creſt,
Boſom'd in rock, her azure ores arreſt;

Feaſt without blood! l. 278. The benevolence of the great Author of all things is greatly manifeſt in the ſum of his works, as Dr. Balguy has well evinced in his pamphlet on Divine Benevolence aſſerted, printed for Davis, 1781. Yet if we may compare the parts of nature with each other, there are ſome circumſtances of her economy which ſeem to contribute more to the general ſcale of happineſs than others. Thus the nouriſhment of animal bodies is derived from three ſources: 1. the milk given from the mother to the offspring; in this excellent contrivance the mother has pleaſure in affording the ſuſtenance to the child, and the child has pleaſure in receiving it. 2. Another ſource of the food of animals includes ſeeds or eggs; in theſe the embryon is in a torpid or inſenſible ſtate, and there is along with it laid up for its early nouriſhment a ſtore of proviſion, as the fruit belonging to ſome ſeeds, and the oil and ſtarch belonging to others; when theſe are conſumed by animals the unfeeling ſeed or egg receives no pain, but the animal receives pleaſure which conſumes it. Under this article may be included the bodies of animals which die naturally. 3. But the laſt method of ſupporting animal bodies by the deſtruction of other living animals, as lions preying upon lambs, theſe upon living vegetables, and mankind upon them all, would appear to be a leſs perfect part of the economy of nature than thoſe before mentioned, as contributing leſs to the ſum of general happineſs.

Mona's rifted creſt. 279. Alluding to the very valuable copper-mines in the iſle of Angleſey, the property of the Earl of Uxbridge.

With iron lips his rapid rollers ſeize
The lengthening bars, in thin expanſion ſqueeze;
Deſcending ſcrews with ponderous fly-wheels wound
The tawny plates, the new medallions round;
Hard dyes of ſteel the cupreous circles cramp,
And with quick fall his maſſy hammers ſtamp.
The Harp, the Lily and the Lion join,
And GEORGE and BRITAIN guard the ſterling coin.

"Soon ſhall thy arm, UNCONQUER'D STEAM! afar
Drag the ſlow barge, or drive the rapid car;
Or on wide-waving wings expanded bear
The flying-chariot through the fields of air.

With iron-lips. l. 281. Mr. Boulton has lately conſtructed at Soho near Birmingham, a moſt magnificent apparatus for Coining, which has coſt him ſome thouſand pounds; the whole machinery is moved by an improved ſteam-engine, which rolls the copper for half-pence finer than copper has before been rolled for the purpoſe of making money; it works the coupoirs or ſcrew-preſſes for cutting out the circular pieces of copper; and coins both the faces and edges of the money at the ſame time, with ſuch ſuperior excellence and cheapneſs of workmanſhip, as well as with marks of ſuch powerful machinery as muſt totally prevent clandeſtine imitation, and in conſequence ſave many lives from the hand of the executioner; a circumſtance worthy the attention of a great miniſter. If a civic crown was given in Rome for preſerving the life of one citizen, Mr. Boulton ſhould be covered with garlands of oak! By this machinery four boys of ten or twelve years old are capable of ſtriking thirty thouſand guineas in an hour, and the machine itſelf keeps an unerring account of the pieces ſtruck.

—Fair crews triumphant, leaning from above,
Shall wave their fluttering kerchiefs as they move;
Or warrior-bands alarm the gaping crowd,
And armies ſhrink beneath the ſhadowy cloud.

"So mighty HERCULES o'er many a clime
Waved his vaſt mace in Virtue's cauſe ſublime,

So mighty Hercules. l. 297. The ſtory of Hercules ſeems of great antiquity, as appears from the ſimplicity of his dreſs and armour, a lion's ſkin and a club; and from the nature of many of his exploits, the deſtruction of wild beaſts and robbers. This part of the hiſtory of Hercules ſeems to have related to times before the invention of the bow and arrow, or of ſpinning flax. Other ſtories of Hercules are perhaps of later date, and appear to be allegorical, as his conquering the river-god Achilous, and bringing Cerberus up to day light; the former might refer to his turning the courſe of a river, and draining a moraſs, and the latter to his expoſing a part of the ſuperſtition of the times. The ſtrangling the lion and tearing his jaws aſunder, are deſcribed from a ſtatue in the Muſeum Florentinum, and from an antique gem; and the graſping Anteus to death in his arms as he lifts him from the earth, is deſcribed from another antient cameo. The famous pillars of Hercules have been variouſly explained. Pliny aſſerts that the natives of Spain and of Africa believed that the mountains of Abyla and Calpè on each ſide of the ſtraits of Gibraltar were the pillars of Hercules; and that they were reared by the hands of that god, and the ſea admitted between them. Plin. Hiſt. Nat. p. 46. Edit. Manut. Venet. 1609.

If the paſſage between the two continents was opened by an earthquake in antient times, as this allegorical ſtory would ſeem to countenance, there muſt have been an immenſe current of water at firſt run into the Mediterranean from the Atlantic; ſince there is at preſent a ſtrong ſtream ſets always from thence into the Mediterranean. Whatever may be the cauſe, which now conſtantly operates, ſo as to make the ſurface of the Mediterranean lower than that of the Atlantic, it muſt have kept it very much lower before a paſſage for the water through the ſtreights was opened. It is probable before ſuch an event took place, the coaſts and iſlands of the Mediterranean extended

Unmeaſured ſtrength with early art combined,
Awed, ſerved, protected, and amazed mankind.—
Firſt two dread Snakes at JUNO's vengeful nod
Climb'd round the cradle of the ſleeping God;
Waked by the ſhrilling hiſs, and ruſtling ſound,
And ſhrieks of fair attendants trembling round,
Their gaſping throats with clenching hands he holds;
And Death untwiſts their convoluted folds.
Next in red torrents from her ſevenfold heads
Fell HYDRA's blood on Lerna's lake he ſheds;
Graſps ACHELOUS with reſiſtleſs force,
And drags the roaring River to his courſe;
Binds with loud bellowing and with hideous yell
The monſter Bull, and threefold Dog of Hell.

"Then, where Nemea's howling foreſts wave,
He drives the Lion to his duſky cave;

and further into that ſea, and were then for a great extent of country, deſtroyed by the floods occaſioned by the new riſe of water, and have ſince remained beneath the ſea. Might not this give riſe to the flood of Deucalion? See note Caſſia, V. II. of this work.

Seized by the throat the growling fiend disarms,
And tears his gaping jaws with sinewy arms;
Lifts proud ANTEUS from his mother-plains,
And with strong grasp the struggling Giant strains;
Back falls his fainting head, and clammy hair,
Writhe his weak limbs, and flits his life in air;—
By steps reverted o'er the blood-dropp'd fen
He tracks huge CACUS to his murderous den;
Where breathing flames through brazen lips he fled,
And shakes the rock-roof'd cavern o'er his head.

"Last with wide arms the solid earth He tears,
Piles rock on rock, on mountain mountain rears;
Heaves up huge ABYLA on Afric's sand,
Crowns with high CALPE Europe's saliant strand,
Crests with opposing towers the splendid scene,
And pours from urns immense the sea between.—
—Loud o'er her whirling flood Charybdis roars,
Affrighted Scylla bellows round his shores,

Veſuvio groans through all his echoing caves,
And Etna thunders o'er the inſurgent waves.

VII. 1. Nymphs! your fine hands ethereal floods amaſs
From the warm cuſhion, and the whirling glaſs;
Beard the bright cylinder with golden wire,
And circumfuſe the gravitating fire.
Cold from each point cerulean luſtres gleam,
Or ſhoot in air the ſcintillating ſtream.
So, borne on brazen talons, watch'd of old
The ſleepleſs dragon o'er his fruits of gold;

Ethereal floods amaſs. l. 335. The theory of the accumulation of the electric fluid by means of the glaſs-globe and cuſhion is difficult to comprehend. Dr. Franklin's idea of the pores of the glaſs being opened by the friction, and thence rendered capable of attracting more electric fluid, which it again parts with, as the pores contract again, ſeems analogous in ſome meaſure to the heat produced by the vibration, or condenſation of bodies, as when a nail is hammered or filed till it becomes hot, as mentioned in additional Notes, No. VII. Some philoſophers have endeavoured to account for this phenomenon by ſuppoſing the exiſtence of two electric fluids which may be called the vitreous and reſinous ones, inſtead of the plus and minus of the ſame ether. But its accumulation on the rubbed glaſs bears great analogy to its accumulation on the ſurface of the Leyden bottle, and can not perhaps be explained from any known mechanical or chemical principle. See note on Gymnotus. l. 202, of this Canto.

Cold from each point. l. 339. See additional note, No. XIII.

Bright beam'd his ſcales, his eye-balls blazed with ire,
And his wide noſtrils breath'd inchanted fire.

"You bid gold-leaves, in cryſtal lantherns held,
Approach attracted, and recede repel'd;
While paper-nymphs inſtinct with motion riſe,
And dancing fauns the admiring Sage ſurprize.
Or, if on wax ſome fearleſs Beauty ſtand,
And touch the ſparkling rod with graceful hand;
Through her fine limbs the mimic lightnings dart,
And flames innocuous eddy round her heart;
O'er her fair brow the kindling luſtres glare,
Blue rays diverging from the briſtling hair;
While ſome fond Youth the kiſs ethereal ſips.
And ſoft fires iſſue from their meeting lips.

You bid gold leaves. l. 345. Alluding to the very ſenſible electrometer improved by Mr. Bennett, it conſiſts of two ſlips of gold-leaf ſuſpended from a tin cap in a glaſs cylinder, which has a partial coating without, communicating with the wooden pedeſtal. If a ſtick of ſealing wax be rubbed for a moment on a dry cloth, and then held in the air *at the diſtance of two or three feet* from the cap of this inſtrument, the gold leaves ſeperate, ſuch is its aſtoniſhing ſenſibility to electric influence! (See Bennet on electricity, Johnſon, Lond.) The nerves of ſenſe of animal bodies do not ſeem to be affected by leſs quantities of light or heat!

So round the virgin Saint in ſilver ſtreams
The holy Halo ſhoots it's arrowy beams.

"You crowd in coated jars the denſer fire,
Pierce the thin glaſs, and fuſe the blazing wire;
Or dart the red flaſh through the circling band
Of youths and timorous damſels, hand in hand.
—Starts the quick Ether through the fibre-trains
Of dancing arteries, and of tingling veins,
Goads each fine nerve, with new ſenſation thrill'd,
Bends the reluctant limbs with power unwill'd;

The holy Halo. l. 358. I believe it is not known with certainty at what time the painters firſt introduced the luminous circle round the head to import a Saint or holy perſon. It is now become a part of the ſymbolic language of painting, and it is much to be wiſhed that this kind of hieroglyphic character was more frequent in that art; as it is much wanted to render hiſtoric pictures both more intelligible, and more ſublime; and why ſhould not painting as well as poetry expreſs itſelf in metaphor, or in indiſtinct allegory? A truly great modern painter lately endeavoured to enlarge the ſphere of pictorial language, by putting a demon behind the pillow of a wicked man on his death bed. Which unfortunately for the ſcientific part of painting, the cold criticiſm of the preſent day has depreciated; and thus barred perhaps the only road to the further improvement in this ſcience.

With new ſenſation thrill'd. l. 365. There is probably a ſyſtem of nerves in animal bodies for the purpoſe of perceiving heat; ſince the degree of this fluid is ſo neceſſary to health that we become preſently injured either by its acceſs or defect; and becauſe almoſt every part of our bodies is ſupplied with branches from different pairs of nerves, which

Palfy's cold hands the fierce concuffion own,
And Life clings trembling on her tottering throne.—
So from dark clouds the playful lightning fprings,
Rives the firm oak, or prints the Fairy-rings.

2. NYMPHS! on that day YE fhed from lucid eyes.
Celeftial tears, and breathed ethereal fighs!

would not feem neceffary for their motion alone. It is therefore probable, that our fenfation of electricity is only of its violence in paffing through our fyftem by its fuddenly diftending the mufcles, like any other mechanical violence; and that it is general pain alone that we feel, and not any fenfation analogous to the fpecific quality of the object. Nature may feem to have been niggardly to mankind in beftowing upon them so few fenfes; fince a fenfe to have perceived electricity, and another to have perceived magnetifm might have been of great fervice to them, many ages before thefe fluids were difcovered by accidental experiment, but it is poffible an increafed number of fenfes might have incommoded us by adding to the fize of our bodies.

Palfy's cold hands. l. 435. Paralytic limbs are in general only incapable of being ftimulated into action by the power of the will; fince the pulfe continues to beat and the fluids to be abforbed in them; and it commonly happens, when paralytic people yawn and ftretch themfelves, (which is not a voluntary motion,) that the affected limb moves at the fame time. The temporary motion of a paralytic limb is likewife caufed by paffing the electric fhock through it; which would feem to indicate fome analogy between the electric fluid, and the nervous fluid, which is feperated from the blood by the brain, and and thence diffufed along the nerves for the purpofes of motion and fenfation. It probably deftroys life by its fudden expanfion of the nerves or fibres of the brain; in the fame manner as it fufes metals and fplinters wood or ftone, and removes the atmofphere, when it paffes from one object to another in a denfe ftate.

Prints the Fairy rings. l. 370. See additional note No. XIII.

When RICHMAN rear'd, by fearleſs haſte betray'd,
The wiry rod in Nieva's fatal ſhade;—
Clouds o'er the Sage, with fringed ſkirts ſucceed,
Flaſh follows flaſh, the warning corks recede;
Near and more near He ey'd with fond amaze
The ſilver ſtreams, and watch'd the ſaphire blaze,
Then burſts the ſteel, the dart electric ſped,
And the bold Sage lay number'd with the dead!—
NYMPHS! on that day YE ſhed from lucid eyes
Celeſtial tears, and breathed ethereal ſighs!

"YOU led your FRANKLIN to your glazed retreats,
Your air-built caſtles, and your ſilken ſeats;

When Richman reared. l. 373. Dr. Richman Profeſſor of natural philoſophy at Peterſburgh about the year 1763, elevated an inſulated metallic rod to collect the aerial electricity, as Dr. Franklin had previouſly done at Philadelphia; and as he was obſerving the repulſion of the balls of his electrometer approached too near the conductor, and receiving the lightening in his head with a loud exploſion, was ſtruck dead amidſt his family.

You led your Franklin. l. 383. Dr. Franklin was the firſt that diſcovered that lightening conſiſted of electric matter, he elevated a tall rod with a wire wrapped round it, and fixing the bottom of a rod into a glaſs bottle, and preſerving it from falling by means of ſilk-ſtrings, he found it electrified whenever a cloud paſſed over it, receiving ſparks by his finger from it, and charging coated phials. This great diſcovery taught us to defend houſes and ſhips and temples from lightning, and alſo to underſtand, *that people are*

Bade his bold arm invade the lowering ſky,
And ſeize the tiptoe lightnings, ere they fly;
O'er the young Sage your myſtic mantle ſpread,
And wreath'd the crown electric round his head.—
Thus when on wanton wing intrepid Love
Snatch'd the raiſed lightning from the arm of Jove;
Quick o'er his knee the triple bolt He bent,
The cluſter'd darts and forky arrows rent,
Snapp'd with illumin'd hands each flaming ſhaft,
His tingling fingers ſhook, and ſtamp'd, and laugh'd;

always perfectly ſafe in a room during a thunder ſtorm if they keep themſelves at three or four feet diſtance from the walls; for the matter of lightning in paſſing from the clouds to the earth, or from the earth to the clouds, runs through the walls of a houſe, the trunk of a tree, or other elevated object; except there be ſome moiſter body, as an animal in contact with them, or nearly ſo; and in that caſe the lightning leaves the wall or tree, and paſſes through the animal; but as it can paſs through metals with ſtill greater facility, it will leave animal bodies to paſs through metallic ones.

If a perſon in the open air be ſurprized by a thunderſtorm, he will know his danger by obſerving on a ſecond watch the time which paſſes between the flaſh and the crack, and reckoning a mile for every four ſeconds and a half, and a little more. For ſound travels at the rate of 1142 feet in a ſecond of time, and the velocity of light through ſuch ſmall diſtances is not to be eſtimated. In theſe circumſtances a perſon will be ſafer by lying down on the ground, than erect, and ſtill ſafer if within a few feet of his horſe; which being then a more elevated animal will receive the ſhock in preference as the cloud paſſes over. See additional notes, No. XIII.

Intrepid Love. l. 389. This allegory is uncommonly beautiful, repreſenting Divine Juſtice as diſarmed by Divine Love, and relenting of his purpoſe. It is expreſſed on an agate in the Great Duke's collection at Florence. Spence.

Bright o'er the floor the ſcatter'd fragments blaz'd,
And Gods retreating trembled as they gaz'd;
The immortal Sire, indulgent to his child,
Bow'd his ambroſial locks, and Heaven relenting ſmiled.

VIII. "When Air's pure eſſence joins the vital flood,
And with phoſphoric Acid dyes the blood,
YOUR VIRGIN TRAINS the tranſient HEAT diſpart,
And lead the ſoft combuſtion round the heart;

Tranſient heat diſpart. l. 401. Dr. Crawford in his ingenious work on animal heat has endeavoured to prove, that during the combination of the pure part of the atmoſphere with the phlogiſtic part of the blood, that much of the matter of the heat is given out from the air; and that this is the great and perpetual ſource of the heat of animals; to which we may add that the phoſphoric acid is probably produced by this combination; by which acid the colour of the blood is changed in the lungs from a deep crimſon to a bright ſcarlet. There ſeems to be however another ſource of animal heat, though of a ſimilar nature; and that is from the chemical combinations produced in all the glands; ſince by whatever cauſe any glandular ſecretion is increaſed, as by friction or topical imflammation, the heat of that part becomes increaſed at the ſame time; thus after the hands have been for a time immerſed in ſnow, on coming into a warm room, they become red and hot, without any increaſed pulmonary action. BESIDES THIS there would ſeem to be another material received from the air, by reſpiration; which is ſo neceſſary to life, that the embryon muſt learn to breath almoſt within a minute after its birth, or it dies. The perpetual neceſſity of breathing ſhews, that the material thus acquired is perpetually conſuming or eſcaping, and on that account requires perpetual renovation. Perhaps the ſpirit of animation itſelf is thus acquired from the atmoſphere, which if it be ſuppoſed to be finer or more ſubtle than the electric matter, could not long be retained in our bodies, and muſt therefore require perpetual renovation.

Life's holy lámp with fires ſucceſſive feed,
From the crown'd forehead to the proſtrate weed,
From Earth's proud realms to all that ſwim or ſweep
The yielding ether or tumultuous deep.
You ſwell the bulb beneath the heaving lawn,
Brood the live ſeed, unfold the burſting ſpawn;
Nurſe with ſoft lap, and warm with fragrant breath
The embryon panting in the arms of Death;
Youth's vivid eye with living light adorn,
And fire the riſing bluſh of Beauty's golden morn.

"Thus when the Egg of Night, on Chaos hurl'd,
Burſt, and diſcloſed the cradle of the world;

Thus when the egg of Night. l. 413. There were two Cupids belonging to the antient mythology, one much elder than the other. The elder cupid, or Eros, or divine Love, was the firſt that came out of the great egg of night, wich floated in Chaos, and was broken by the horns of the celeſtial bull, that is, was hatched by the warmth of the ſpring. He was winged and armed, and by his arrows and torch pierced and vivified all things, producing life and joy. Bacon, Vol. V. p. 197. Quarto edit. Lond. 1778. "At this "time, (ſays Ariſtophanes,) ſable-winged night produced an egg, from whence ſprung "up like a bloſſom Eros, the lovely, the deſirable, with his gloſſy golden wings." Avibus. Bryant's Mythology, Vol. II. p. 350. ſecond edition. This intereſting moment of this ſublime allegory Mrs. Coſway has choſen for her very beautiful painting.

Firſt from the gaping ſhell refulgent ſprung
Immortal Love, his bow celeſtial ſtrung;—
O'er the wide waſte his gaudy wings unfold,
Beam his ſoft ſmiles, and wave his curls of gold;—
With ſilver darts He pierced the kindling frame,
And lit with torch divine the ever-living flame."

IX. The Goddess pauſed, admired with conſcious pride
The effulgent legions marſhal'd by her ſide,
Forms ſphered in fire wirh trembling light array'd,
Ens without weight, and ſubſtance without ſhade;
And, while tumultuous joy her boſom warms,
Waves her white hand, and calls her hoſts to arms,

"Unite, illustrious Nymphs! your radiant powers,
Call from their long repoſe the Vernal Hours.

She has repreſented Eros or divine Love with large wings having the ſtrength of the eagle's wings, and the ſplendor of the peacocks, with his hair floating in the form of flame, and with a halo of light vapour round his head; which illuminates the painting; while he is in the act of ſpringing forwards, and with his hands ſeparating the elements.

Wake with ſoft touch, with roſy hands unbind
The ſtruggling pinions of the WESTERN WIND;
Chafe his wan cheeks, his ruffled plumes repair,
And wring the rain-drops from his tangled hair.
Blaze round each froſted rill, or ſtagnant wave,
And charm the NAIAD from her ſilent cave;
Where, ſhrined in ice, like NIOBE ſhe mourns,
And claſps with hoary arms her empty urns.

Of the Weſtern Wind. l. 430. The principal froſts of this country are accompanied or produced by a N.E. wind, and the thaws by a S.W. wind; the reaſon of which is that the N.E. winds conſiſt of regions of air brought from the north, which appear to acquire an eaſterly direction as they advance; and the S.W. winds conſiſt of regions of air brought from the ſouth, which appear to acquire a weſterly direction as they advance. The ſurface of the earth nearer the pole moves ſlower than it does in our latitude; whence the regions of air brought from thence, move ſlower, when they arrive hither, than the earth's ſurface with which they now become in contact; that is they acquire an apparent eaſterly direction, as the earth moves from weſt to eaſt faſter than this new part of its atmoſphere. The S.W. winds on the contrary conſiſt of regions of air brought from the ſouth, where the ſurface of the earth moves faſter than in our latitude; and have therefore a weſterly direction when they arrive hither by their moving faſter than the ſurface of the earth, with which they are in contact; and in general the nearer to the weſt and the greater the velocity of theſe winds the warmer they ſhould be in reſpect to the ſeaſon of the year, ſince they have been brought more expeditiouſly from the ſouth, than thoſe winds which have leſs weſterly direction, and have thence been leſs cooled in their paſſage.

Sometimes I have obſerved the thaw to commence immediately on the change of the wind, even within an hour, if I am not miſtaken, or ſooner. At other times the S.W. wind has continued a day, or even two, before the thaw has commenced; during which time ſome of the froſty air, which had gone ſouthwards, is driven back over us; and in conſequence has taken a weſterly direction, as well as a ſouthern one. At other times I have obſerved a froſt with a N.E. wind every morning, and a thaw with a S.W. wind every noon for ſeveral days together. See additional note, XXXIII.

Call your bright myriads, trooping from afar,
With beamy helms, and glittering shafts of war;
In phalanx firm the FIEND OF FROST assail,
Break his white towers, and pierce his crystal mail;
To Zembla's moon-bright coasts the Tyrant bear,
And chain him howling to the Northern Bear.

"So when enormous GRAMPUS, issuing forth
From the pale regions of the icy North;

The Fiend of Frost. l. 439. The principal injury done to vegetation by frost is from the expansion of the water contained in the vessels of plants. Water converted into ice occupies a greater space than it did before, as appears by the bursting of bottles filled with water at the time of their freezing. Hence frost destroys those plants of our island first, which are most succulent; and the most succulent parts first of other plants; as the leaves and last year's shoots; the vessels of which are distended and burst by the expansion of their freezing fluids, while the drier or more resinous plants, as pines, yews, laurels, and other ever-greens, are less liable to injury from cold. The trees in vallies are on this account more injured by the vernal frosts than those on eminencies, because their early succulent shoots come out sooner. Hence fruit trees covered by a six-inch coping of a wall are less injured by the vernal frosts because their being shielded from showers and the descending night-dews has prevented them from being moist at the time of their being frozen: which circumstance has given occasion to a vulgar error amongst gardeners, who suppose frost to descend.

As the common heat of the earth in this climate is 48 degrees, those tender trees which will bear bending down, are easily secured from the frost by spreading them upon the ground, and covering them with straw or fern. This particularly suits fig-trees, as they easily bear bending to the ground, and are furnished with an acrid juice, which secures them from the depredations of insects; but are nevertheless liable to be eaten by mice. See additional notes, No. XII.

Waves his broad tail, and opes his ribbed mouth,
And ſeeks on winnowing fin the breezy South;
From towns deſerted ruſh the breathleſs hoſts,
Swarm round the hills, and darken all the coaſts;
Boats follow boats along the ſhouting tides,
And ſpears and javelins pierce his blubbery ſides;
Now the bold Sailor, raiſed on pointed toe,
Whirls the wing'd harpoon on the ſlimy foe;
Quick ſinks the monſter in his oozy bed,
The blood-ſtain'd ſurges circling o'er his head,
Steers to the frozen pole his wonted track,
And bears the iron tempeſt on his back.

X. "On wings of flame, ETHEREAL VIRGINS! ſweep
O'er Earth's fair boſom, and complacent deep;
Where dwell my vegetative realms benumb'd,
In buds impriſon'd, or in bulbs intomb'd,

In buds impriſon'd. l. 460. The buds and bulbs of plants conſtitute what is termed by Linneus the Hybernaculum, or winter cradle of the embryon vegetable. The buds ariſe from the bark on the branches of trees, and the bulbs from the caudex of bulbous-

Pervade, PELLUCID FORMS! their cold retreat,
Ray from bright urns your viewlefs floods of *heat*;

rooted plants, or the part from which the fibres of the root are produced, they are defended from too much moifture, and from frofts, and from the depredations of infects by various contrivances, as by fcales, hairs, refinous varnifhes, and by acrid rinds.

The buds of trees are of two kinds, either flower-buds or leaf buds; the former of thefe produce their feeds and die; the latter produce other leaf buds or flower buds and die. So that all the buds of trees may be confidered as annual plants, having their embryon produced during the preceeding fummer. The fame feems to happen with refpect to bulbs; thus a tulip produces annually one flower-bearing bulb, fometimes two, and feveral leaf-bearing bulbs; and then the old root perifhes. Next year the flower-bearing bulb produces feeds and other bulbs and perifhes, while the leaf-bearing bulb, producing other bulbs only, perifhes likewife; thefe circumftances eftablifh a ftrict analogy between bulbs and buds. See additional notes, No. XIV.

Viewlefs floods of heat. l. 462. The fluid matter of heat, or Calorique, in which all bodies are immerfed, is as neceffary to vegetable as to animal exiftence. It is not yet determinable whether heat and light be different materials, or modifications of the fame materials, as they have fome properties in common. They appear to be both of them equally neceffary to vegetable health, fince without light green vegetables become firft yellow, that is, they lofe the blue colour, which contributed to produce the green; and afterwards they alfo lofe the yellow and become white; as is feen in cellery blanched or etiolated for the table by excluding the light from it.

The upper furface of leaves, which I fuppofe to be their organ of refpiration, feems to require light as well as air; fince plants which grow in windows on the infide of houfes are equally follicitous to turn the upper fide of their leaves to the light. Vegetables at the fame time exfude or perfpire a great quantity from their leaves, as animals do from their lungs; this perfpirable matter as it rifes from their fine veffels, (perhaps much finer than the pores of animal fkins,) is divided into inconcievable tenuity; and when acted upon by the Sun's light appears to be decompofed; the hydrogene becomes a part of the vegetable, compofing oils or refins; and the Oxygene combined with light or calorique afcends, producing the pure part of the atmofphere or vital air. Hence during the light of the day vegetables give up more pure air than their refpiration injures; but not fo in the night, even though equally expofed to warmth. This fingle fact would feem to fhew, that light is effentially different from heat; and it is perhaps by its combination with bodies, that their combined or latent heat is fet at liberty, and becomes fenfible. See additional note, XXXIV.

From earth's deep waſtes *electric* torrents pour,
Or ſhed from heaven the ſcintillating ſhower;
Pierce the dull root, relax its fibre-trains,
Thaw the thick blood, which lingers in its veins;

Electric torrents pour. l. 463. The influence of electricity in forwarding the germination of plants and their growth ſeems to be pretty well eſtabliſhed; though Mr. Ingenhouz did not ſucceed in his experiments, and thence doubts the ſucceſs of thoſe of others. And though M. Rouland from his new experiments believes, that neither poſitive nor negative electricity increaſes vegetation; both which philoſophers had previouſly been ſupporters of the contrary doctrine; for many other naturaliſts have ſince repeated their experiments relative to this object, and their new reſults have confirmed their former ones. Mr. D'Ormoy and the two Roziers have found the ſame ſucceſs in numerous experiments which they have made in the laſt two years; and Mr. Carmoy has ſhewn in a convincing manner that electricity accelerates germination.

Mr. D'Ormoy not only found various ſeeds to vegetate ſooner, and to grow taller which were put upon his inſulated table and ſupplied with electricity, but alſo that ſilk-worms began to ſpin much ſooner which were kept electrified than thoſe of the ſame hatch which were kept in the ſame place and manner, except that they were not electrified. Theſe experiments of M. D'Ormoy are detailed at length in the Journal de Phyſique of Rozier, Tom. XXXV. p. 270.

M. Bartholon, who had before written a tract on this ſubject, and propoſed ingenious methods for applying electricity to agriculture and gardening, has alſo repeated a numerous ſet of experiments; and ſhews both that natural electricity, as well as the artificial, increaſes the growth of plants, and the germination of ſeeds; and oppoſes Mr. Ingenhouz by very numerous and concluſive facts. Ib. Tom. XXXV. p. 401.

Since by the late diſcoveries or opinions of the Chemiſts there is reaſon to believe that water is decompoſed in the veſſels of vegetables; and that the Hydrogene or inflammable air, of which it in part conſiſts, contributes to the nouriſhment of the plant, and to the production of its oils, roſins, gums, ſugar, &c. and laſtly as electricity decompoſes water into theſe two airs termed Oxygene and Hydrogene, there is a powerful analogy to induce us to believe that it accelerates or contributes to the growth of vegetation, and like heat may poſſibly enter into combination with many bodies, or form the baſis of ſome yet unanaliſed acid.

Melt with warm breath the fragrant gums, that bind
The expanding foliage in its ſcaly rind;
And as in air the laughing leaflets play,
And turn their ſhining boſoms to the ray,
NYMPHS! with ſweet ſmile each opening flower invite,
And on its damaſk eyelids pour the *light*.

"So ſhall my pines, Canadian wilds that ſhade,
Where no bold ſtep has pierc'd the tangled glade,
High-towering palms, that part the Southern flood
With ſhadowy iſles and continents of wood,
Oaks, whoſe broad antlers creſt Britannia's plain,
Or bear her thunders o'er the conquer'd main,
Shout, as you paſs, inhale the genial ſkies,
And baſk and brighten in your beamy eyes;
Bow their white heads, admire the changing clime,
Shake from their candied trunks the tinkling rime;
With burſting buds their wrinkled barks adorn,
And wed the timorous floret to her thorn;

Deep ſtrike their roots, their lengthening tops revive,
And all my world of foliage wave, alive.

"Thus with Hermetic art the ADEPT combines
The royal acid with cobaltic mines;
Marks with quick pen, in lines unſeen portrayed,
The bluſhing mead, green dell, and duſky glade;
Shades with pellucid clouds the tintleſs field,
And all the future Group exiſts conceal'd;
Till waked by fire the dawning tablet glows,
Green ſprings the herb, the purple floret blows,
Hills vales and woods in bright ſucceſſion riſe,
And all the living landſcape charms his eyes.

IX. "With creſt of gold ſhould ſultry SIRIUS glare,
And with his kindling treſſes ſcorch the air;

Thus with Hermetic art. l. 487. The ſympathetic inks made by Zaffre diſſolved in the marine and nitrous acids have this curious property, that being brought to the fire one of them becomes green, and the other red; but what is more wonderful, they again loſe theſe colours, (unleſs the heat has been too great,) on their being again withdrawn from the fire. Fire-ſcreens have been thus painted, which in the cold have ſhewn only the trunk and branches of a dead tree, and ſandy hills, which on their approach to the fire have put forth green leaves and red flowers, and graſs upon the mountains. The proceſs of making theſe inks is very eaſy, take Zaffre, as ſold by the druggiſts, and digeſt

With points of flame the ſhafts of Summer arm,
And burn the beauties he deſigns to warm;—
—So erſt when JOVE his oath extorted mourn'd,
And clad in glory to the Fair return'd;
While Loves at forky bolts their torches light,
And reſting lightnings gild the car of Night;
His blazing form the dazzled Maid admir'd,
Met with fond lips, and in his arms expir'd;—
NYMPHS! on light pinion lead your banner'd hoſts
High o'er the cliffs of ORKNEY's gulphy coaſts;
Leave on your left the red volcanic light,
Which HECCLA lifts amid the duſky night;
Mark on the right the DOFRINE's ſnow-capt brow,
Where whirling MAELSTROME roars and foams below;
Watch with unmoving eye, where CEPHEUS bends
His triple crown, his ſcepter'd hand extends;

it in aqua regia, and the calx of Cobalt will be diſſolved; which ſolution muſt be diluted with a little common water to prevent it from making too ſtrong an impreſſion on the paper; the colour when the paper is heated becomes of a fine green-blue. If Zaffre or Regulus of Cobalt be diſſolved in the ſame manner in ſpirit of nitre, or aqua fortis, a reddiſh colour is produced on expoſing the paper to heat. Chemical Dictionary by Mr. Keir, Art. Ink Sympathetic.

Where ſtuds CASSIOPE with ſtars unknown
Her golden chair, and gems her ſapphire zone;
Where with vaſt convolution DRACO holds
The ecliptic axis in his ſcaly folds,
O'er half the ſkies his neck enormous rears,
And with immenſe meanders parts the BEARS;
Onward, the kindred BEARS with footſtep rude
Dance round the Pole, purſuing and purſued.

"There in her azure coif and ſtarry ſtole,
Grey TWILIGHT ſits, and rules the ſlumbering Pole;
Bends the pale moon-beams round the ſparkling coaſt,
And ſtrews with livid hands eternal froſt.
There, NYMPHS! alight, array your dazzling powers,
With ſudden march alarm the torpid Hours;

With ſtars unknown. l. 515. Alluding to the ſtar which appeared in the chair of Caſſiopea in the year 1572, which at firſt ſurpaſſed Jupiter in magnitude and brightneſs, diminiſhed by degrees and diſappeared in 18 months; it alarmed all the aſtronomers of the age, and was eſteemed a comet by ſome.—Could this have been the Georgium ſidus?

On ice-built iſles expand a thouſand ſails,
Hinge the ſtrong helms, and catch the frozen gales;

On ice-built iſles. l. 529. There are many reaſons to believe from the accounts of travellers and navigators, that the iſlands of ice in the higher northern latitudes as well as the Glaciers on the Alps continue perpetually to increaſe in bulk. At certain times in the ice-mountains of Switzerland there happen cracks which have ſhewn the great thickneſs of the ice, as ſome of theſe cracks have meaſured three or four hundred ells deep. The great iſlands of ice in the northern ſeas near Hudſon's bay have been obſerved to have been immerſed above one hundred fathoms beneath the ſurface of the ſea, and to have riſen a fifth or ſixth part above the ſurface, and to have meaſured between three and four miles in circumference. Phil. Tranſ. No. 465. Sect. 2.

Dr. Liſter endeavoured to ſhew that the ice of ſea-water contains ſome ſalt and perhaps leſs air than common ice, and that it is therefore much more difficult of ſolution; whence he accounts for the perpetual and great increaſe of theſe floating iſlands of ice. Philoſ. Tranſ. No. 169.

As by a famous experiment of Mr. Boyles it appears that ice evaporates very faſt in ſevere froſty weather when the wind blows upon it; and as ice in a thawing ſtate is known to contain ſix times more cold than water at the ſame degree of ſenſible coldneſs, it is eaſy to underſtand that winds blowing over iſlands and continents of ice perhaps much below nothing on Farenheit's ſcale, and coming from thence into our latitude muſt bring great degrees of cold along with them. If we add to this the quantity of cold produced by the evaporation of the water as well as by the ſolution of the ice, we cannot doubt but that the northern ice is the principle ſource of the coldneſs of our winters, and that it is brought hither by the regions of air blowing from the north, and which take an apparent eaſterly direction by their coming to a part of the ſurface of the earth which moves faſter than the latitude they come from. Hence the increaſe of the ice in the polar regions by increaſing the cold of our climate adds at the ſame time to the bulk of the Glaciers of Italy and Switzerland.

If the nations who inhabit this hemiſphere of the globe, inſtead of deſtroying their ſea-men and exhauſting their wealth in unneceſſary wars, could be induced to unite their labours to navigate theſe immenſe maſſes of ice into the more ſouthern oceans, two great advantages would reſult to mankind, the tropic countries would be much cooled by their ſolution, and our winters in this latitude would be rendered much milder for perhaps a century or two, till the maſſes of ice became again enormous.

Mr. Bradley aſcribes the cold winds and wet weather which ſometimes happen in May and June to the ſolution of ice-iſlands accidentally floating from the north. Treatiſe on Huſbandry and Gardening, Vol. II. p. 437. And adds, that Mr. Barham about

The winged rocks to feveriſh climates guide,
Where fainting Zephyrs pant upon the tide;
Paſs, where to CEUTA CALPE's thunder roars,
And anſwering echoes ſhake the kindred ſhores;
Paſs, where with palmy plumes CANARY ſmiles,
And in her ſilver girdle binds her iſles;
Onward, where NIGER's duſky Naiad laves
A thouſand kingdoms with prolific waves,
Or leads o'er golden ſands her threefold train
In ſteamy channels to the fervid main,
While ſwarthy nations croud the ſultry coaſt,
Drink the freſh breeze, and hail the floating Froſt,

the year 1718, in his voyage from Jamaica to England in the beginning of June, met with ice-iſlands coming from the north, which were ſurrounded with ſo great a fog that the ſhip was in danger of ſtriking upon them, and that one of them meaſured ſixty miles in length.

We have lately experienced an inſtance of ice-iſlands brought from the Southern polar regions, on which the Guardian ſtruck at the beginning of her paſſage from the Cape of Good Hope towards Botany Bay, on December 22, 1789. Theſe iſlands were involved in miſt, were about one hundred and fifty fathoms long, and about fifty fathoms above the ſurface of the water. A part from the top of one of them broke off and fell into the ſea, cauſing an extraordinary commotion in the water and a thick ſmoke all round it.

Threefold train. l. 537. The river Niger after traverſing an immenſe tract of populous country is ſuppoſed to divide itſelf into three other great rivers. The Rio Grande, the Gambia, and the Senegal. Gold-duſt is obtained from the ſands of theſe rivers.

Nymphs! veil'd in mift, the melting treafures fteer,
And cool with arctic fnows the tropic year.
So from the burning Line by Monfoons driven
Clouds fail in fquadrons o'er the darken'd heaven;
Wide waftes of fand the gelid gales pervade,
And ocean cools beneath the moving fhade.

XII. Should Solstice, ftalking through the fickening bowers,
Suck the warm dew-drops, lap the falling fhowers;
Kneel with parch'd lip, and bending from it's brink
From dripping palm the fcanty river drink;
Nymphs! o'er the foil ten thoufand points erect,
And high in air the electric flame collect.

Wide waftes of fand. l. 545. When the fun is in the Southern tropic 36 deg. diftant from the zenith, the thermometer is feldom lower than 72 deg. at Gondar in Abyffinia, but it falls to 60 or 53 deg. when the fun is immediatly vertical; fo much does the approach of rain counteract the heat of the fun. Bruce's Travels, Vol. 3. p. 670.

Ten thoufand points erect. l. 551. The folution of water in air or in calorique, feems to acquire electric matter at the fame time, as appears from an experiment of Mr. Bennet. He put fome live coals into an infulated funnel of metal, and throwing on them a little water obferved that the afcending fteam was electrifed plus, and the water which de-

Soon ſhall dark miſts with ſelf-attraction ſhroud
The blazing day, and ſail in wilds of cloud;
Each ſilvery Flower the ſtreams aerial quaff,
Bow her ſweet head, and infant Harveſt laugh.

"Thus when ELIJA mark'd from Carmel's brow
In bright expanſe the briny flood below;
Roll'd his red eyes amid the ſcorching air,
Smote his firm breaſt, and breathed his ardent prayer;
High in the midſt a maſſy altar ſtood,
And ſlaughter'd offerings preſs'd the piles of wood;
While ISRAEL's chiefs the ſacred hill ſurround,
And famiſh'd armies crowd the duſty ground;

ſcended through the funnel was electrifed minus. Hence it appears that though clouds by their change of form may ſometimes become electriſed minus yet they have in general an accumulation of electricity. This accumulation of electric matter alſo evidently contributes to ſupport the atmoſpheric vapour when it is condenſed into the form of clouds, becauſe it is ſeen to deſcend rapidly after the flaſhes of lightning have diminiſhed its quantity; whence there is reaſon to conclude that very numerous metallic rods with fine points erected high in the air might induce it at any time to part with ſome of its water.

If we may truſt the theory of Mr. Lavoiſier concerning the compoſition and decompoſition of water, there would ſeem another ſource of thunder-ſhowers; and that is, that the two gaſſes termed oxygene gas or vital air, and hydrogene gas or inflammable air, may exiſt in the ſummer atmoſphere in a ſtate of mixture but not of combination, and that the electric ſpark or flaſh of lightning may combine them and produce water inſtantaneouſly.

While proud Idolatry was leagued with dearth,
And wither'd famine ſwept the deſert earth.—
"OH, MIGHTY LORD! thy woe-worn ſervant hear,
"Who calls thy name in agony of prayer;
"Thy fanes diſhonour'd, and thy prophets ſlain,
"Lo! I alone ſurvive of all thy train!—
"Oh ſend from heaven thy ſacred fire,—and pour
"O'er the parch'd land the ſalutary ſhower,—
"So ſhall thy Prieſt thy erring flock recal,—
"And ſpeak in thunder, "THOU ART LORD OF ALL."—
He cried, and kneeling on the mountain-ſands,
Stretch'd high in air his ſupplicating hands.
—Deſcending flames the duſky ſhrine illume;
Fire the wet wood, the ſacred bull conſume;
Wing'd from the ſea the gathering miſts ariſe,
And floating waters darken all the ſkies;
The King with ſhifted reins his chariot bends,
And wide o'er earth the airy flood deſcends;
With mingling cries diſperſing hoſts applaud,
And ſhouting nations own THE LIVING GOD."

The Goddess ceaſed,—the exulting tribes obey,
Start from the ſoil, and win their airy way ;
The vaulted ſkies with ſtreams of tranſient rays
Shine, as they paſs, and earth and ocean blaze.
So from fierce wars when lawleſs Monarch's ceaſe,
Or Liberty returns with laurel'd Peace ;
Bright fly the ſparks, the colour'd luſtres burn,
Flaſh follows flaſh, and flame-wing'd circles turn ;
Blue ſerpents ſweep along the duſky air,
Imp'd by long trains of ſcintillating hair ;
Red rockets riſe, loud cracks are heard on high,
And ſhowers of ſtars ruſh headlong from the ſky,
Burſt, as in ſilver lines they hiſs along,
And the quick flaſh unfolds the gazing throng.

Argument of the Second Canto.

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THE

ECONOMY OF VEGETATION.

CANTO II.

AND NOW THE GODDESS with attention ſweet
Turns to the GNOMES, that circle round her feet;
Orb within orb approach the marſhal'd trains,
And pigmy legions darken all the plains;
Thrice ſhout with ſilver tones the applauding bands,
Bow, ere She ſpeaks, and clap their fairy hands.

So the tall graſs, when noon-tide zephyr blows,
Bends it's green blades in undulating rows;
Wide o'er the fields the billowy tumult ſpreads,
And ruſtling harveſts bow their golden heads.

I. "GNOMES! YOUR bright forms, preſiding at her birth,
Clung in fond ſquadrons round the new-born EARTH;
When high in ether, with explosion dire,
From the deep craters of his realms of fire,
The whirling Sun this ponderous planet hurl'd,
And gave the aſtoniſh'd void another world.
When from it's vaporous air, condenſed by cold,
Deſcending torrents into oceans roll'd;

From the deep craters. l. 14. The exiſtence of ſolar volcanos is countenanced by their analogy to terreſtrial, and lunar volcanos; and by the ſpots on the ſun's diſk, which have been ſhewn by Dr. Wilſon to be excavations through its luminous ſurface, and may be ſuppoſed to be the cavities from whence the planets and comets were ejected by exploſions. See additional notes, No. XV. on ſolar volcanos.

When from its vaporous air. l. 17. If the nucleus of the earth was thrown out from the ſun by an exploſion along with as large a quantity of ſurrounding hot vapour as its attraction would occaſion to accompany it, the ponderous ſemi-fluid nucleus would take a ſpherical form from the attraction of its own parts, which would become an oblate ſpheroid from its diurnal revolution. As the vapour cooled the water would be preci-

And fierce attraction with relentleſs force
Bent the reluctant wanderer to it's courſe.

"Where yet the Bull with diamond-eye adorns
The Spring's fair forehead, and with golden horns;
Where yet the Lion climbs the ethereal plain,
And ſhakes the Summer from his radiant mane;
Where Libra lifts her airy arm, and weighs,
Poiſed in her ſilver ballance, nights and days;
With paler luſtres where Aquarius burns,
And ſhowers the ſtill ſnow from his hoary urns;
YOUR ardent troops purſued the flying ſphere,
Circling the ſtarry girdle of the year;
While ſweet viciſſitudes of day and clime
Mark'd the new annals of enaſcent Time.

pitated, and an ocean would ſurround the ſpherical nucleus with a ſuperincumbent atmoſphere. The nucleus of ſolar lava, would likewiſe become harder as it became cooler. To underſtand how the ſtrata of the earth were afterwards formed from the ſediments of this circumfluent ocean the reader is referred to an ingenious Treatiſe on the Theory of the Earth by Mr. Whitehurſt, who was many years a watch-maker and engineer at Derby, but whoſe ingenuity, integrity, and humanity, were rarely equalled in any ſtation of life.

II. "You trod with printleſs ſtep Earth's tender globe,
While Ocean wrap'd it in his azure robe;
Beneath his waves her hardening ſtrata ſpread,
Raiſed her PRIMEVAL ISLANDS from his bed,

While ocean wrap'd. l. 34. See additional notes, No. XVI. on the production of calcareous earth.

Her hardening ſtrata ſpread. l. 35. The granite, or moor-ſtone, or porphory, conſtitute the oldeſt part of the globe, ſince the limeſtone, ſhells, coralloids, ond other ſea-productions reſt upon them; and upon theſe ſea-productions are found clay, iron, coal, ſalt, and ſiliceous ſand or grit-ſtone. Thus there ſeem to be three diviſions of the globe diſtinctly marked; the firſt I ſuppoſe to have been the original nucleus of the earth, or lava projected from the ſun; 2. over this lie the recrements of animal and vegetable matter produced in the ocean; and, 3. over theſe the recrements of animal and vegetable matter produced upon the land. Beſides theſe there are bodies which owe their origin to a combination of thoſe already mentioned, as ſiliceous ſand, fluor, alabaſter; which ſeem to have derived their acids originally from the vegetable kingdom, and their earthy baſes from ſea-productions. See additional notes, No. XVI. on calcareous earth.

Raiſed her primeval iſlands. l. 36. The nucleus of the earth, ſtill covered with water, received perpetual increaſe by the immenſe quantities of ſhells and coralloids either annually produced and relinquiſhed, or left after the death of the animals. Theſe would gradually by their different degrees of coheſion be ſome of them more and others leſs removable by the influence of ſolar tides, and gentle tropical breezes, which then muſt have probably extended from one pole to the other; for it is ſuppoſed the moon was not yet produced, and that no ſtorms or unequal winds had yet exiſtence.

Hence then the primeval iſlands had their gradual origin, were raiſed but a few feet above the level of the ſea, and were not expoſed to the great or ſudden variations of heat and cold, as is ſo well explained in Mr. Whitehurſt's Theory of the Earth, chap. xvi. Whence the paradiſe of the ſacred writers, and the golden age of the profane ones, ſeems to have had a real exiſtence. As there can be no rainbow, when the heavens are covered with clouds, becauſe the ſun-beams are then precluded from falling upon the rain-drops oppoſite to the eye of the ſpectator, the rainbow is a mark of gentle or partial ſhowers. Mr. Whitehurſt has endeavoured to ſhow that the primitive iſlands were only moiſtened

Stretch'd her wide lawns, and ſunk her winding dells,
And deck'd her ſhores with corals, pearls, and ſhells.

"O'er thoſe bleſt iſles no ice-crown'd mountains tower'd,
No lightnings darted, and no tempeſts lower'd;
Soft fell the veſper-drops, condenſed below,
Or bent in air the rain-refracted bow;
Sweet breathed the zephyrs, juſt perceiv'd and loſt;
And brineleſs billows only kiſs'd the coaſt;
Round the bright zodiac danced the vernal hours,
And Peace, the Cherub, dwelt in mortal bowers!

by nocturnal dews and not by ſhowers, as occurs at this day to the Delta of Egypt; and is thence of opinion, that the rainbow had no exiſtence till after the production of mountains and continents. As the ſalt of the ſea has been gradually accumulating, being waſhed down into it from the recrements of animal and vegetable bodies, the ſea muſt originally have been as freſh as river water; and as it is not yet ſaturated with ſalt, muſt become annually more ſaline. See note on l. 117 of this Canto.

So young Dione. l. 47. There is an antient gem repreſenting Venus riſing out of the ocean ſupported by two Tritons. From the formality of the deſign it would appear to be of great antiquity before the introduction of fine taſte into the world. It is probable that this beautiful allegory was originally an hieroglyphic picture (before the invention of letters) deſcriptive of the formation of the earth from the ocean, which ſeems to have been an opinion of many of the moſt antient philoſophers.

"So young DIONE, nurſed beneath the waves,
And rock'd by Nereids in their coral caves,
Charm'd the blue ſiſterhood with playful wiles,
Liſp'd her ſweet tones, and tried her tender ſmiles.
Then, on her beryl throne by Triton's borne,
Bright roſe the Goddeſs like the Star of morn;
When with ſoft fires the milky dawn He leads,
And wakes to life and love the laughing meads;—
With roſy fingers, as uncurl'd they hung
Round her fair brow, her golden locks ſhe wrung;
O'er the ſmooth ſurge on ſilver ſandals ſtood,
And look'd enchantment on the dazzled flood.—
The bright drops, rolling from her lifted arms,
In ſlow meanders wander o'er her charms,
Seek round her ſnowy neck their lucid track,
Pearl her white ſhoulders, gem her ivory back,
Round her fine waiſt and ſwelling boſom ſwim,
And ſtar with glittering brine each cryſtal limb.—

—The immortal form enamour'd Nature hail'd,
And Beauty blazed to heaven and earth, unvail'd.

III. "You! who then, kindling after many an age,
Saw with new fires the firſt VOLCANO rage,
O'er ſmouldering heaps of livid ſulphur ſwell
At Earth's firm centre, and diſtend her ſhell,

The firſt volcano. l. 68. As the earth before the exiſtence of earthquakes was nearly level, and the greateſt part of it covered with ſea; when the firſt great fires began deep in the internal parts of it, thoſe parts would become much expanded; this expanſion would be gradually extended, as the heat increaſed, through the whole terraqueous globe of 7000 miles diameter; the cruſt would thence in many places open into fiſſures, which by admitting the ſea to flow in upon the fire, would produce not only a quantity of ſteam beyond calculation by its expanſion, but would alſo by its decompoſition produce inflammable air and vital air in quantities beyond conception, ſufficient to effect thoſe violent exploſions, the veſtiges of which all over the world excite our admiration and our ſtudy; the difficulty of underſtanding how ſubterraneous fires could exiſt without the preſence of air has diſappeared ſince Dr. Prieſtley's diſcoveries of ſuch great quantities of pure air which conſtitute all the acids, and conſequently exiſt in all ſaline bodies, as ſea-ſalt, nitre, lime-ſtone, and in all calciform ores, as mangareſe, calamy, ochre, and other mineral ſubſtances. See an ingenious treatiſe by Mr. Michel on earthquakes in the Philoſ. Tranſ.

In theſe firſt tremendous ignitions of the globe, as the continents were heaved up, the vallies, which now hold the ſea, were formed by the earth ſubſiding into the cavities made by the riſing mountains; as the ſteam, which raiſed them condenſed; which would thence not have any caverns of great extent remain beneath them, as ſome philoſophers have imagined. The earthquakes of modern days are of very ſmall extent indeed compared to thoſe of antient times, and are ingeniouſly compared by M. De Luc to the operations of a mole-hill, where from a ſmall cavity are raiſed from time to time ſmall quantities of lava or pumice ſtone. Monthly Review, June, 1790.

Saw at each opening cleft the furnace glow,
And ſeas ruſh headlong on the gulphs below.—
GNOMES! how you ſhriek'd! when through the troubled air
Roar'd the fierce din of elemental war;
When roſe the continents, and ſunk the main,
And Earth's huge ſphere exploding burſt in twain.—
GNOMES! how you gazed! when from her wounded ſide
Where now the South-Sea heaves its waſte of tide,
Roſe on ſwift wheels the MOON's refulgent car,
Circling the ſolar orb, a ſiſter-ſtar,
Dimpled with vales, with ſhining hills emboſs'd,
And roll'd round Earth her airleſs realms of froſt.

The moon's refulgent car. l. 77. See additional notes, No. XV. on ſolar volcanos.

Her airleſs realms of froſt. l. 82. If the moon had no atmoſphere at the time of its elevation from the earth; or if its atmoſphere was afterwards ſtolen from it by the earth's attraction; the water on the moon would riſe quickly into vapour, and the cold produced by a certain quantity of this evaporation would congeal the remainder of it. Hence it is not probable that the moon is at preſent inhabited, but as it ſeems to have ſuffered and to continue to ſuffer much by volcanos, a ſufficient quantity of air may in proceſs of time be generated to produce an atmoſphere; which may prevent its heat from ſo eaſily eſcaping, and its water from ſo eaſily evaporating, and thence become fit for the production of vegetables and animals.

That the moon poſſeſſes little or no atmoſphere is deduced from the undiminiſhed luſtre of the ſtars, at the inſtant when they emerge from behind her diſk. That the

"Gnomes! how you trembled! with the dreadful force
When Earth recoiling ſtagger'd from her courſe;
When, as her Line in ſlower circles ſpun,
And her ſhock'd axis nodded from the ſun,
With dreadful march the accumulated main
Swept her vaſt wrecks of mountain, vale, and plain;
And, while new tides their ſhouting floods unite,
And hail their Queen, fair Regent of the night;

ocean of the moon is frozen, is confirmed from there being no appearance of lunar tides; which, if they exiſted, would cover the part of her diſk neareſt the earth. See note on Canto III. l. 61.

When earth recoiling. l. 84. On ſuppoſition that the moon was thrown from the earth by the exploſion of water or the generation of other vapours of greater power, the remaining part of the globe would recede from its orbit in one direction as the moon receded in another, and that in proportion to the reſpective momentum of each, and would afterwards revolve round their common centre of gravity.

If the moon roſe from any part of the earth except exactly at the line or poles, the ſhock would tend to turn the axis of the earth out of its previous direction. And as a maſs of matter riſing from deep parts of the globe would have previouſly acquired leſs diurnal velocity than the earth's ſurface from whence it roſe, it would receive during the time of its riſing additional velocity from the earth's ſurface, and would conſequently ſo much retard the motion of the earth round its axis.

When the earth thus receded the ſhock would overturn all its buildings and foreſts, and the water would ruſh with inconceivable violence over its ſurface towards the new ſatellite, from two cauſes, both by its not at firſt acquiring the velocity with which the earth receded, and by the attraction of the new moon, as it leaves the earth; on theſe accounts at firſt there would be but one tide till the moon receded to a greater diſtance, and the earth moving round a common centre of gravity between them, the water on the ſide furtheſt from the moon would acquire a centrifugal force in reſpect to this common centre between itſelf and the moon.

Chain'd to one centre whirl'd the kindred ſpheres,
And mark'd with lunar cycles ſolar years.

IV. "GNOMES! YOU then bade diſſolving SHELLS diſtil
From the looſe ſummits of each ſhatter'd hill,
To each fine pore and dark interſtice flow,
And fill with liquid chalk the maſs below.
Whence ſparry forms in duſky caverns gleam
With borrow'd light, and twice refract the beam;
While in white beds congealing rocks beneath
Court the nice chiſſel, and deſire to breathe.—

Diſſolving ſhells diſtil. l. 93. The lime-ſtone rocks have had their origin from ſhells formed beneath the ſea, the ſofter ſtrata gradually diſſolving and filling up the interſtices of the harder ones, afterwards when theſe accumulations of ſhells were elevated above the waters the upper ſtrata became diſſolved by the actions of the air and dews, and filled up the interſtices beneath, producing ſolid rocks of different kinds from the coarſe lime-ſtones to the fineſt marbles. When thoſe lime-ſtones have been in ſuch a ſituation that they could form perfect cryſtals they are called ſpars, ſome of which poſſeſs a double refraction, as obſerved by Sir Iſaac Newton. When theſe cryſtals are jumbled together or mixed with ſome colouring impurities it is termed marble, if its texture be equable and firm; if its texture be coarſe and porous yet hard, it is called lime-ſtone; if its texture be very looſe and porous it is termed chalk. In ſome rocks the ſhells remain almoſt unchanged and only covered, or bedded with lime-ſtone, which ſeems to have been diſſolved and ſunk down amongſt them. In others the ſofter ſhells and bones are diſſolved, and only ſharks teeth or harder echini have preſerved their form inveloped in the chalk or lime-ſtone; in ſome marbles the ſolution has been compleat and no veſtiges of ſhell appear, as in the white kind called ſtatuary by the workmen. See addit. notes, No. XVI.

" Hence wearied HERCULES in marble rears
His languid limbs, and reſts a thouſand years;
Still, as he leans, ſhall young ANTINOUS pleaſe
With careleſs grace, and unaffected eaſe;
Onward with loftier ſtep APOLLO ſpring,
And launch the unerring arrow from the ſtring;
In Beauty's baſhful form, the veil unfurl'd,
Ideal VENUS win the gazing world.
Hence on ROUBILIAC's tomb ſhall Fame ſublime
Wave her triumphant wings, and conquer Time;
Long with ſoft touch ſhall DAMER's chiſſel charm,
With grace delight us, and with beauty warm;

Hence wearied Hercules. l. 101. Alluding to the celebrated Hercules of Glyco reſting after his labours; and to the eaſy attitude of Antinous; the lofty ſtep of the Apollo of Belvidere; and the retreating modeſty of the Venus de Medici. Many of the deſigns by Roubiliac in Weſtminſter Abbey are uncommonly poetical; the allegory of Time and Fame contending for the trophy of General Wade, which is here alluded to, is beautifully told; the wings of Fame are ſtill expanded, and her hair ſtill floating in the air; which not only ſhews that ſhe has that moment arrived, but alſo that her force is not yet expended; at the ſame time, that the old figure of Time with his diſordered wings is rather leaning backwards and yielding to her impulſe, and muſt apparently in another inſtant be driven from his attack upon the trophy.

Foster's fine form ſhall hearts unborn engage,
And Melbourn's ſmile enchant another age.

V. Gnomes! you then taught tranſuding dews to paſs
Through time-fall'n woods, and root-inwove moraſs
Age after age; and with filtration fine
Diſpart, from earths and ſulphurs, the ſaline.

1. "Hence with diffuſive Salt old Ocean ſteeps
His emerald ſhallows, and his ſapphire deeps.

Foſter's fine form. l. 113. Alluding to the beautiful ſtatues of Lady Elizabeth Foſter and of Lady Melbourn executed by the ingenious Mrs. Damer.

Root-inwove moraſs. l. 116. The great maſs of matter which reſts upon the lime-ſtone ſtrata of the earth, or upon the granite where the lime-ſtone ſtratum has been removed by earthquakes or covered by lava, has had its origin from the recrements of vegetables and of air-breathing animals, as the lime-ſtone had its origin from ſea animals. The whole habitable world was originally covered with woods, till mankind formed themſelves into ſocieties, and ſubdued them by fire and by ſteel. Hence woods in uncultivated countries have grown and fallen through many ages, whence moraſſes of immenſe extent; and from theſe as the more ſoluble parts were waſhed away firſt, were produced ſea-ſalt, nitre, iron, and variety of acids, which combining with calcareous matter were productive of many foſſil bodies, as flint, ſea-ſand, ſelenite, with the precious ſtones, and perhaps the diamond. See additional notes, No. XVII.

Hence with diffuſive ſalt. l. 119. Salts of various kinds are produced from the recrements of animal and vegetable bodies, ſuch as phoſphoric, ammoniacal, marine ſalt, and

Oft in wide lakes, around their warmer brim
In hollow pyramids the crystals swim;
Or, fused by earth-born fires, in cubic blocks
Shoot their white forms, and harden into rocks. 124

others; these are washed from the earth by rains, and carried down our rivers into the sea; they seem all here to decompose each other except the marine salt, which has therefore from the beginning of the habitable world been perpetually accumulating.

There is a town in the immense salt-mines of Cracow in Poland, with a market-place, a river, a church, and a famous statue, (here supposed to be of Lot's wife) by the moist or dry appearance of which the subterranean inhabitants are said to know when the weather is fair above ground. The galleries in these mines are so numerous and so intricate, that workmen have frequently lost their way, their lights having been burnt out, and have perished before they could be found. Essais, &c. par M. Macquart. And though the arches of these different stories of galleries are boldly executed, yet they are not dangerous; as they are held together or supported by large masses of timber of a foot square; and these vast timbers remain perfectly sound for many centuries, while all other pillars whether of brick, cement, or salt soon dissolve or moulder away. Ibid. Could the timbers over water-mill wheels or cellars, be thus preserved by occasionally soaking them with brine? These immense masses of rock-salt seem to have been produced by the evaporation of sea-water in the early periods of the world by subterranean fires. Dr. Hutton's Theory of the Earth. See also Theorie des Sources Salees, par Mr. Struve. Histoire de Sciences de Lausanne. Tom. II. This idea of Dr. Hutton's is confirmed by a fact mentioned in M. Macquart's Essais sur Minerologie, who found a great quantity of fossil shells, principally bi-valves and madre-pores, in the salt-mines of Wialiczka near Cracow. During the evaporation of the lakes of salt-water, as in artificial salt-works, the salt begins to crystallize near the edges where the water is shallowest, forming hollow inverted pyramids; which, when they become of a certain size, subside by their gravity; if urged by a stronger fire the salt fuses or forms large cubes; whence the salt shaped in hollow pyramids, called flake-salt, is better tasted and preserves flesh better, than the basket or powder salt; because it is made by less heat and thence contains more of the marine acid. The sea-water about our island contains from about one twenty-eighth to one thirtieth part of sea-salt, and about one eightieth of magnesian salt. See Brownrigg on Salt. See note on Ocymum, Vol. II. of this work.

" Thus, cavern'd round in CRACOW's mighty mines,
With cryſtal walls a gorgeous city ſhines;
Scoop'd in the briny rock long ſtreets extend
Their hoary courſe, and glittering domes aſcend;
Down the bright ſteeps, emerging into day,
Impetuous fountains burſt their headlong way,
O'er milk-white vales in ivory channels ſpread,
And wondering ſeek their ſubterraneous bed.
Form'd in pellucid ſalt with chiſſel nice,
The pale lamp glimmering through the ſculptured ice,
With wild reverted eyes fair LOTTA ſtands,
And ſpreads to Heaven, in vain, her glaſſy hands;
Cold dews condenſe upon her pearly breaſt,
And the big tear rolls lucid down her veſt.
Far gleaming o'er the town tranſparent fanes
Rear their white towers, and wave their golden vanes;
Long lines of luſtres pour their trembling rays,
And the bright vault returns the mingled blaze.

2. "HENCE orient NITRE owes it's ſparkling birth,
And with priſmatic cryſtals gems the earth,
O'er tottering domes in filmy foliage crawls,
Or froſts with branching plumes the mouldering walls.

Hence orient Nitre. l. 143. Nitre is found in Bengal naturally cryſtallized, and is ſwept by brooms from earths and ſtones, and thence called ſweepings of nitre. It has lately been found in large quantities in a natural baſon of calcareous earth at Molfetta in Italy, both in thin ſtrata between the calcareous beds, and in effloreſcences of various beautiful leafy and hairy forms. An account of this nitre-bed is given by Mr. Zimmerman and abridged in Rozier's Journal de Phyſique Fevrier. 1790. This acid appears to be produced in all ſituations where animal and vegetable matters are compleatly decompoſed, and which are expoſed to the action of the air as on the walls of ſtables, and ſlaughter-houſes; the cryſtals are priſms furrowed by longitudinal groves.

Dr. Prieſtley diſcovered that nitrous air or gas which he obtained by diſſolving metals in nitrous acid, would combine rapidly with vital air, and produce with it a true nitrous acid; forming red clouds during the combination; the two airs occupy only the ſpace before occupied by one of them, and at the ſame time heat is given out from the new combination. This dimunition of the bulk of a mixture of nitrous gas and vital air, Dr. Prieſtley ingeniouſly uſed as a teſt of the purity of the latter; a diſcovery of the greateſt importance in the analyſis of airs.

Mr. Cavendiſh has ſince demonſtrated that two parts of vital air or oxygene, and one part of phlogiſtic air or azote, being long expoſed to electric ſhocks, unite, and produce nitrous acid. Philoſ. Tranſ. Vols. LXXV. and LXXVIII.

Azote is one of the moſt abundant elements in nature, and combined with calorique or heat, it forms azotic gas or phlogiſtic air, and compoſes two thirds of the atmoſphere; and is one of the principal component parts of animal bodies, and when united to vital air or oxygene produces the nitrous acid. Mr. Lavoiſier found that 21½ parts by weight of azote, and 43½ parts of oxygene produced 64 parts of nitrous gas, and by the further addition of 36 parts of oxygene nitrous acid was produced. Traité de Chimie. When two airs become united ſo as to produce an unelaſtic liquid much calorique or heat is of neceſſity expelled from the new combination, though perhaps nitrous acid and oxygenated marine acid admit more heat into their combinations than other acids.

As woos Azotic Gas the virgin Air,
And veils in crimſon clouds the yielding Fair,
Indignant Fire the treacherous courtſhip flies,
Waves his light wing, and mingles with the ſkies.

" So Beauty's GODDESS, warm with new deſire,
Left, on her ſilver wheels, the GOD of Fire;
Her faithleſs charms to fiercer MARS reſign'd,
Met with fond lips, with wanton arms intwin'd.
—Indignant VULCAN eyed the parting Fair,
And watch'd with jealous ſtep the guilty pair;
O'er his broad neck a wiry net he flung,
Quick as he ſtrode, the tinkling meſhes rung;
Fine as the ſpider's flimſy thread He wove
The immortal toil to lime illicit love;
Steel were the knots, and ſteel the twiſted thong,
Ring link'd in ring, indiſſolubly ſtrong;
On viewleſs hooks along the fretted roof
He hung, unſeen, the inextricable woof.—

—Quick ſtart the ſprings, the webs pellucid ſpread,
And lock the embracing Lovers on their bed;
Fierce with loud taunts vindictive VULCAN ſprings,
Tries all the bolts, and tightens all the ſtrings,
Shakes with inceſſant ſhouts the bright abodes,
Claps his rude hands, and calls the feſtive Gods.—
—With ſpreading palms the alarmed Goddeſs tries
To veil her beauties from celeſtial eyes,
Writhes her fair limbs, the ſlender ringlets ſtrains,
And bids her Loves untie the obdurate chains;
Soft ſwells her panting boſom, as ſhe turns,
And her fluſh'd cheek with brighter bluſhes burns.
Majeſtic grief the Queen of Heaven avows,
And chaſte Minerva hides her helmed brows;
Attendant Nymphs with baſhful eyes aſkance
Steal of intangled MARS a tranſient glance;
Surrounding Gods the circling nectar quaff,
Gaze on the Fair, and envy as they laugh.

III. " Hence duſky Iron ſleeps in dark abodes,
And ferny foliage neſtles in the nodes;
Till with wide lungs the panting bellows blow,
And waked by fire the glittering torrents flow;

Hence duſky Iron. l. 183. The production of iron from the decompoſition of vegetable bodies is perpetually preſented to our view; the waters oozing from all moraſſes are chalybeate, and depoſit their ochre on being expoſed to the air, the iron acquiring a calciform ſtate from its union with oxygene or vital air. Where thin moraſſes lie on beds of gravel the latter are generally ſtained by the filtration of ſome of the chalybeate water through them. This formation of iron from vegetable recrements is further evinced by the fern leaves and other parts of vegetables, ſo frequently found in the centre of the knobs or nodules of ſome iron-ores.

In ſome of theſe nodules there is a nucleus of whiter iron-earth ſurrounded by many concentric ſtrata of darker and lighter iron-earth alternately. In one, which now lies before me, the nucleus is a priſm of a triangular form with blunted angles, and about half an inch high, and an inch and half broad; on every ſide of this are concentric ſtrata of ſimilar iron-earth alternately browner and leſs brown; each ſtratum is about a tenth of an inch in thickneſs and there are ten of them in number. To what known cauſe can this exactly regular diſtribution of ſo many earthy ſtrata of different colours ſurrounding the nucleus be aſcribed? I dont know that any mineralogiſts have attempted an explanation of this wonderful phenomenon. I ſuſpect it is owing to the polarity of the central nucleus. If iron-filings be regularly laid on paper by means of a ſmall ſieve, and a magnet be placed underneath, the filings will diſpoſe themſelves in concentric curves with vacant intervals between them. Now if theſe iron-filings are conceived to be ſuſpended in a fluid, whoſe ſpecific gravity is ſimilar to their own, and a magnetic bar was introduced as an axis into this fluid, it is eaſy to foreſee that the iron filings would diſpoſe themſelves into concentric ſpheres, with intervals of the circumnatant fluid between them, exactly as is ſeen in theſe nodules of iron-earth. As all the lavas conſiſt of one fourth of iron, (Kirvan's Mineral) and almoſt all other known bodies, whether of animal or vegetable origin, poſſeſs more or leſs of this property, may not the diſtribution of a great portion of the globe of the earth into ſtrata of greater or leſs regularity be owing to the polarity of the whole?

—Quick whirls the wheel, the ponderous hammer falls,
Loud anvils ring amid the trembling walls,
Strokes follow ſtrokes, the ſparkling ingot ſhines,
Flows the red ſlag, the lengthening bar refines;
Cold waves, immerſed, the glowing maſs congeal,
And turn to adamant the hiſſing Steel.

"Laſt Michell's hands with touch of potent charm
The poliſh'd rods with powers magnetic arm;

And turn to adamant. l. 192. The circumſtances which render iron more valuable to mankind than any other metal are, 1. its property of being rendered hard to ſo great a degree and thus conſtituting ſuch excellent tools. It was the diſcovery of this property of iron, Mr. Locke thinks, that gave ſuch pre-eminence to the European world over the American one. 2. Its power of being welded; that is, when two pieces are made very hot and applied together by hammering, they unite compleatly, unleſs any ſcale of iron intervenes; and to prevent this it is uſual for ſmiths to dip the very hot bar in ſand, a little of which fuſes into fluid glaſs with the ſcale and is ſqueezed out from between the uniting parts by the force of hammering. 3. Its power of acquiring magnetiſm.

It is however to be wiſhed that gold or ſilver were diſcovered in as great quantity as iron, ſince theſe metals being indeſtructible by expoſure to air, water, fire or any common acids would ſupply wholeſome veſſels for cookery, ſo much to be deſired, and ſo difficult to obtain, and would form the moſt light and durable coverings for houſes, as well as indeſtructible fire-grates, ovens, and boiling veſſels. See additional notes, No. XVIII. on Steel.

Laſt Michell's hands. l. 193. The diſcovery of the magnet ſeems to have been in very early times; it is mentioned by Plato, Lucretius, Pliny, and Galen, and is ſaid to have taken its name of magnes from Magneſia, a ſea-port of antient Lybia.

As every piece of iron which was made magnetical by the touch of a magnet became itſelf a magnet, many attempts were made to improve theſe artificial magnets, but without much ſucceſs till Servingdon Savary, Eſq. made them of *hardened* ſteel bars, which

With points directed to the polar ſtars
In one long line extend the temper'd bars;

were ſo powerful that one of them weighing three pounds averdupois would lift another of the ſame weight. Philoſ. Tranſ.

After this Dr. Knight made very ſucceſsful experiments on this ſubject, which, though he kept his method ſecret, ſeems to have excited others to turn their attention to magnetiſm. At this time the Rev. Mr. Michell invented an equally efficacious and more expeditious way of making ſtrong artificial magnets, which he publiſhed in the end of the year 1750, in which he explained his method of what he called "the double touch," and which, ſince Mr. Knight's method has been known, appears to be ſomewhat different from it.

This method of rendering bars of hardened ſteel magnetical conſiſts in holding vertically two or more magnetic bars nearly parallel to each other with their oppoſite poles very near each other, (but nevertheleſs ſeparated to a ſmall diſtance,) theſe are to be ſlided over a line of bars laid horizontally a few times backward and forward. See Michell on Magnetiſm, alſo a detailed account in Chamber's Dictionary.

What Mr. Michell propoſed by this method was to include a very ſmall portion of the horizontal bars, intended to be made magnetical, between the joint forces of two or more bars already magnetical, and by ſliding them from end to end every part of the line of bars became ſucceſſively included, and thus bars poſſeſſed of a very ſmall degree of magnetiſm to begin with, would in a few times ſliding backwards and forwards make the other ones much more magnetical than themſelves, which are then to be taken up and uſed to touch the former, which are in ſucceſſion to be laid down horizontally in a line.

There is ſtill a great field remains for future diſcoveries in magnetiſm both in reſpect to experiment and theory; the latter conſiſts of vague conjectures the more probable of which are perhaps thoſe of Elpinus, as they aſſimulate it to electricity.

One conjecture I ſhall add, viz. that the polarity of magnetiſm may be owing to the earth's rotatory motion. If heat, electricity, and magnetiſm are ſuppoſed to be fluids of different gravities, heat being the heavieſt of them, electricity the next heavy, and magnetiſm the lighteſt, it is evident that by the quick revolution of the earth the heat will be accumulated moſt over the line, electricity next beneath this, and that the magnetiſm will be detruded to the poles and axis of the earth, like the atmoſpheres of common air and of inflammable gas, as explained in the note on Canto I. l. 123.

Electricity and heat will both of them diſplace magnetiſm, and this ſhews that they may gravitate on each other; and hence when too great a quantity of the electric fluid becomes accumulated at the poles by deſcending ſnows, or other unknown cauſes, it may have a tendency to riſe towards the tropics by its centrifugal force, and produce the northern lights. See additional notes, No. I.

Then thrice and thrice with ſteady eye he guides,
And o'er the adheſive train the magnet ſlides;
The obedient Steel with living inſtinct moves,
And veers for ever to the pole it loves.

"Hail, adamantine STEEL! magnetic Lord!
King of the prow, the plowſhare, and the ſword!
True to the pole, by thee the pilot guides
His ſteady helm amid the ſtruggling tides,
Braves with broad ſail the immeaſurable ſea,
Cleaves the dark air, and aſks no ſtar but Thee.—
By thee the plowſhare rends the matted plain,
Inhumes in level rows the living grain;
Intruſive foreſts quit the cultured ground,
And Ceres laughs with golden fillets crown'd.—
O'er reſtleſs realms when ſcowling Diſcord flings
Her ſnakes, and loud the din of battle rings;
Expiring Strength, and vanquiſh'd Courage feel
Thy arm reſiſtleſs, adamantine STEEL!

IV. "Hence in fine ſtreams diffuſive Acids flow,
Or wing'd with fire o'er Earth's fair boſom blow;
Tranſmute to glittering Flints her chalky lands,
Or ſink on Ocean's bed in countleſs Sands.
Hence ſilvery Selenite her chryſtal moulds,
And ſoft Aſbeſtus ſmooths his ſilky folds;
His cubic forms phoſphoric Fluor prints,
Or rays in ſpheres his amethyſtine tints.
Soft cobweb clouds tranſparent Onyx ſpreads,
And playful Agates weave their colour'd threads;

Diffuſive Acids flow. l. 215. The production of marine acid from decompoſing vegetable and animal matters with vital air, and of nitrous acid from azote and vital air, the former of which is united to its baſis by means of the exhalations from vegetable and animal matters, conſtitute an analogy which induces us to believe that many other acids have either their baſes or are united to vital air by means of ſome part of decompoſing vegetable and animal matters.

The great quantities of flint ſand whether formed in mountains or in the ſea would appear to derive its acid from the new world, as it is found above the ſtrata of lime-ſtone and granite which conſtitute the old world, and as the earthy baſis of flint is probably calcareous, a great part of it ſeems to be produced by a conjunction of the new and old world; the recrements of air-breathing animals and vegetables probably afford the acid, and the ſhells of marine animals the earthy baſis, while another part may have derived its calcareous part alſo from the decompoſition of vegetable and animal bodies.

The ſame mode of reaſoning ſeems applicable to the ſiliceous ſtones under various names, as amethyſt, onyx, agate, mochoe, opal, &c. which do not ſeem to have undergone any proceſs from volcanic fires, and as theſe ſtones only differ from flint by a greater or leſs admixture of argillaceous and calcareous earths. The different proportions of which in each kind of ſtone may be ſeen in Mr. Kirwan's valuable Elements of Mineralogy. See additional notes, No. XIX.

Gay pictured Mochoes glow with landſcape-dyes,
And changeful Opals roll their lucid eyes;
Blue lambent light around the Sapphire plays,
Bright Rubies bluſh, and living Diamonds blaze.

"Thus, for attractive earth, inconſtant JOVE
Maſk'd in new ſhapes forſook his realms above.—

Living diamonds blaze. l. 228. Sir Iſaac Newton having obſerved the great power of refracting light, which the diamond poſſeſſes above all other cryſtallized or vitreous matter, conjectured that it was an inflammable body in ſome manner congealed. Inſomuch that all the light is reflected which falls on any of its interior ſurfaces at a greater angle of incidence than 24½ degrees; whereas an artificial gem of glaſs does not reflect any light from its hinder ſurface, unleſs that ſurface is inclined in an angle of 41 degrees. Hence the diamond reflects half as much more light as a factitious gem in ſimilar circumſtances; to which muſt be added its great tranſparency, and the excellent poliſh it is capable of. The diamond had nevertheleſs been placed at the head of cryſtals or precious ſtones by the mineralogiſts, till Bergman ranged it of late in the combuſtible claſs of bodies, becauſe by the focus of Villette's burning mirror it was evaporated by a heat not much greater than will melt ſilver, and gave out light. Mr. Hoepſner however thinks the diſperſion of the diamond by this great heat ſhould be called a phoſphoreſcent evaporation of it, rather than a combuſtion; and from its other analogies of cryſtallization, hardneſs, tranſparency, and place of its nativity, wiſhes again to replace it amongſt the precious ſtones. Obſerv. ſur la Phyſique, par Rozier, Tom. XXXV. p. 448. See new edition of the Tranſlation of Cronſted, by De Coſta.

Inconſtant Jove. l. 229. The purer air or ether in the antient mythology was repreſented by Jupiter, and the inferior air by Juno; and the conjunction of theſe deities was ſaid to produce the vernal ſhowers, and procreate all things, as is further ſpoken of in Canto III. l. 204. It is now diſcovered that pure air, or oxygene, uniting with variety of baſes forms the various kinds of acids; as the vitriolic acid from pure air and ſulphur;

Firſt her ſweet eyes his Eagle-form beguiles,
And HEBE feeds him with ambroſial ſmiles;
Next the chang'd God a Cygnet's down aſſumes,
And playful LEDA ſmooths his gloſſy plumes;
Then glides a ſilver Serpent, treacherous gueſt!
And fair OLYMPIA folds him in her breaſt;
Now lows a milk-white Bull on Afric's ſtrand,
And crops with dancing head the daiſy'd land.—
With roſy wreathes EUROPA's hand adorns
His fringed forehead, and his pearly horns;
Light on his back the ſportive Damſel bounds,
And pleaſed he moves along the flowery grounds;
Bears with ſlow ſtep his beauteous prize aloof,
Dips in the lucid flood his ivory hoof;
Then wets his velvet knees, and wading laves
His ſilky ſides amid the dimpling waves.

the nitrous acid from pure air and phlogiſtic air, or azote; and carbonic acid, (or fixed air,) from pure air and charcoal. Some of theſe affinities were perhaps portrayed by the Magi of Egypt, who were probably learned in chemiſtry, in their hieroglyphic pictures before the invention of letters, by the loves of Jupiter with terreſtrial ladies. And thus phyſically as well as metaphyſically might be ſaid "Jovis omnia plena."

While her fond train with beckoning hands deplore,
Strain their blue eyes, and ſhriek along the ſhore;
Beneath her robe ſhe draws her ſnowy feet,
And, half-reclining on her ermine ſeat,
Round his raiſed neck her radiant arms ſhe throws,
And reſts her fair cheek on his curled brows;
Her yellow treſſes wave on wanton gales,
And high in air her azure mantle ſails.
—Onward He moves, applauding Cupids guide,
And ſkim on ſhooting wing the ſhining tide;
Emerging Triton's leave their coral caves,
Sound their loud conchs, and ſmooth the circling waves,
Surround the timorous Beauty, as ſhe ſwims,
And gaze enamour'd on her ſilver limbs.
—Now Europe's ſhadowy ſhores with loud acclaim
Hail the fair fugitive, and ſhout her name;
Soft echoes warble, whiſpering foreſts nod,
And conſcious Nature owns the preſent God.
—Changed from the Bull, the rapturous God aſſumes
Immortal youth, with glow celeſtial blooms,

With lenient words her virgin fears diſarms,
And claſps the yielding Beauty in his arms;
Whence Kings and Heroes own illuſtrious birth,
Guards of mankind, and demigods on earth.

VI. " Gnomes! as you paſs'd beneath the labouring ſoil,
The guards and guides of Nature's chemic toil,
You ſaw, deep-ſepulchred in duſky realms,
Which Earth's rock-ribbed ponderous vault o'erwhelms,
With ſelf-born fires the maſs fermenting glow,
And flame-wing'd ſulphurs quit the earths below.

I. " Hence ductile Clays in wide expanſion ſpread,
Soft as the Cygnet's down, their ſnow-white bed;

With ſelf-born fires. l. 275. After the accumulation of plains and mountains on the calcareous rocks or granite which had been previouſly raiſed by volcanic fires, a ſecond ſet of volcanic fires were produced by the fermentation of this new maſs, by which after the ſalts or acids and iron had been waſhed away in part by elutriation, diſſipated the ſulphurous parts which were inſoluble in water; whence argillaceous and ſiliceous earths were left in ſome places; in others, bitumen became ſublimed to the upper part of the ſtratum, producing coals of various degrees of purity.

Hence ductile clays. l. 277. See additional notes, No. XX.

With yielding flakes succeſſive forms reveal,
And change obedient to the whirling wheel.
—Firſt CHINA's ſons, with early art elate,
Form'd the gay tea-pot, and the pictured plate;
Saw with illumin'd brow and dazzled eyes
In the red ſtove vitreſcent colours riſe;
Speck'd her tall beakers with enamel'd ſtars,
Her monſter-joſſes, and gigantic jars;
Smear'd her huge dragons with metallic hues,
With golden purples, and cobaltic blues;
Bade on wide hills her porcelain caſtles glare,
And glazed Pagodas tremble in the air.

"ETRURIA! next beneath thy magic hands
Glides the quick wheel, the plaiſtic clay expands,

Saw with illumin'd brow. l. 283. No colour is diſtinguiſhable in the red-hot kiln but the red itſelf, till the workman introduces a ſmall piece of dry wood, which by producing a white flame renders all the other colours viſible in a moment.

With golden purples. l. 288. See additional notes, No. XXI.

Etruria! next. l. 291. Etruria may perhaps vie with China itſelf in the antiquity of its arts. The times of its greateſt ſplendour were prior to the foundations of Rome, and

Nerved with fine touch, thy fingers (as it turns)
Mark the nice bounds of vases, ewers, and urns;
Round each fair form in lines immortal trace
Uncopied Beauty, and ideal Grace.

"GNOMES! as you now dissect with hammers fine
The granite-rock, the nodul'd flint calcine;
Grind with strong arm, the circling chertz betwixt,
Your pure Ka-o-lins and Pe-tun-tses mixt;
O'er each red saggars burning cave preside,
The keen-eyed Fire-Nymphs blazing by your side;

the reign of one of its best princes, Janus, was the oldest epoch the Romans knew. The earliest historians speak of the Etruscans as being then of high antiquity, most probably a colony from Phœnicia, to which a Pelasgian colony acceded, and was united soon after Deucalion's flood. The peculiar character of their earthen vases consists in the admirable beauty, simplicity, and diversity of forms, which continue the best models of taste to the artists of the present times; and in a species of non-vitreous encaustic painting, which was reckoned, even in the time of Pliny, among the lost arts of antiquity, but which has lately been recovered by the ingenuity and industry of Mr. Wedgwood. It is supposed that the principal manufactories were about Nola, at the foot of Vesuvius; for it is in that neighbourhood that the greatest quantities of antique vases have been found; and it is said that the general taste of the inhabitants is apparently influenced by them; insomuch that strangers coming to Naples, are commonly struck with the diversity and elegance even of the most ordinary vases for common uses. See D'Hancarville's preliminary discourses to the magnificent collection of Etruscan vases, published by Sir William Hamilton.



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And pleaſed on WEDGWOOD ray your partial ſmile,
A new Etruria decks Britannia's iſle.—
Charm'd by your touch, the flint liqueſcent pours
Through finer ſieves, and falls in whiter ſhowers;
Charm'd by your touch, the kneaded clay refines,
The biſcuit hardens, the enamel ſhines;
Each nicer mould a ſofter feature drinks,
The bold Cameo ſpeaks, the ſoft Intaglio thinks.

"To call the pearly drops from Pity's eye,
Or ſtay Deſpair's diſanimating ſigh,
Whether, O Friend of art! the gem you mould
Rich with new taſte, with antient virtue bold;
Form the poor fetter'd SLAVE on bended knee
From Britain's ſons imploring to be free;

Form the poor fetter'd Slave. l. 315. Alluding to two cameos of Mr. Wedgwood's manufacture; one of a Slave in chains, of which he diſtributed many hundreds, to excite the humane to attend to and to aſſiſt in the abolition of the deteſtable traffic in human creatures; and the other a cameo of Hope attended by Peace, and Art, and Labour; which was made of clay from Botany Bay; to which place he ſent many of them to ſhew the inhabitants what their materials would do, and to encourage their induſtry. A print of this latter medallion is prefixed to Mr. Stockdale's edition of Philip's Expedition to Botany Bay.

Or with fair Hope the brightening ſcenes improve,
And cheer the dreary waſtes at Sydney-cove;
Or bid Mortality rejoice and mourn
O'er the fine forms on Portland's myſtic urn.—

"*Here* by fall'n columns and disjoin'd arcades,
On mouldering ſtones, beneath deciduous ſhades,
Sits Humankind in hieroglyphic ſtate,
Serious, and pondering on their changeful ſtate;
While with inverted torch, and ſwimming eyes,
Sinks the fair ſhade of Mortal Life, and dies.
There the pale Ghost through Death's wide portal bends
His timid feet, the duſky ſteep deſcends;
With ſmiles aſſuaſive Love Divine invites,
Guides on broad wing, with torch uplifted lights;
Immortal Life, her hand extending, courts
The lingering form, his tottering ſtep ſupports;

Portland's myſtic urn. l. 320. See additional notes, No. XXII.

Leads on to Pluto's realms the dreary way,
And gives him trembling to Elyſian day.
Beneath, in ſacred robes the PRIESTESS dreſs'd,
The coif cloſe-hooded, and the fluttering veſt,
With pointing finger guides the initiate youth,
Unweaves the many-colour'd veil of Truth,
Drives the profane from Myſtery's bolted door,
And Silence guards the Eleuſinian lore:—

" Whether, O Friend of Art! your gems derive
Fine forms from Greece, and fabled Gods revive;
Or bid from modern life the Portrait breathe,
And bind round Honour's brow the laurel wreath;
Buoyant ſhall ſail, with Fame's hiſtoric page,
Each fair medallion o'er the wrecks of age;

Fine forms from Greece. l. 342. In real ſtones, or in paſte or ſoft coloured glaſs, many pieces of exquiſite workmanſhip were produced by the antients. Baſſo-relievos of various ſizes were made in coarſe brown earth of one colour; but of the improved kind of two or more colours, and of a true porcelain texture, none were made by the antients, nor attempted I believe by the moderns, before thoſe of Mr. Wedgwood's manufactory.

Nor Time ſhall mar; nor ſteel, nor fire, nor ruſt
Touch the hard poliſh of the immortal buſt.

2. "Hence ſable Coal his maſſy couch extends,
And ſtars of gold the ſparkling Pyrite blends;
Hence dull-eyed Naphtha pours his pitchy ſtreams,
And Jet uncolour'd drinks the ſolar beams,
Bright Amber ſhines on his electric throne,
And adds ethereal luſtres to his own.
—Led by the phoſphor-light, with daring tread
Immortal Franklin ſought the fiery bed;

Hence ſable Coal. l. 349. See additional notes, No. XXIII. on coal.

Bright Amber ſhines. l. 353. Coal has probably all been ſublimed more or leſs from the clay, with which it was at firſt formed in decompoſing moraſſes; the petroleum ſeems to have been ſeparated and condenſed again in ſuperior ſtrata, and a ſtill finer kind of oil, as naphtha, has probably had the ſame origin. Some of theſe liquid oils have again loſt their more volatile parts, and become cannel-coal, aſphaltum, jet, and amber, according to the purity of the original foſſil oil. Dr. Prieſtley has ſhewn, that eſſential oils long expoſed to the atmoſphere abſorb both the vital and phlogiſtic part of it; whence it is probable their becoming ſolid may in great meaſure depend, as well as by the exhalation of their more volatile parts. On diſtillation with volatile alcaly all theſe foſſil oils are ſhewn to contain the acid of amber, which evinces the identity of their origin. If a piece of amber be rubbed it attracts ſtraws and hairs, whence the diſcovery of electricity, and whence its name, from electron the Greek word for amber.

Immortal Franklin. l. 356. See note on Canto I. l. 383.

Where, nursed in night, incumbent Tempest shrouds
The seeds of Thunder in circumfluent clouds,
Besieged with iron points his airy cell,
And pierced the monster slumbering in the shell.

"So, born on sounding pinions to the WEST,
When Tyrant-Power had built his eagle nest;
While from his eyry shriek'd the famish'd brood,
Clenched their sharp claws, and champ'd their beaks for blood,
Immortal FRANKLIN watch'd the callow crew,
And stabb'd the struggling Vampires, ere they flew.
—The patriot-flame with quick contagion ran,
Hill lighted hill, and man electrised man;
Her heroes slain awhile COLUMBIA mourn'd,
And crown'd with laurels LIBERTY return'd.

"The Warrior, LIBERTY, with bending sails
Helm'd his bold course to fair HIBERNIA's vales;—
Firm as he steps, along the shouting lands,
Lo! Truth and Virtue range their radiant bands;

Sad Superſtition wails her empire torn,
Art plies his oar, and Commerce pours her horn.

"Long had the Giant-form on GALLIA's plains
Inglorious ſlept, unconſcious of his chains;
Round his large limbs were wound a thouſand ſtrings
By the weak hands of Confeſſors and Kings;
O'er his cloſed eyes a triple veil was bound,
And ſteely rivets lock'd him to the ground;
While ſtern Baſtile with iron cage inthralls
His folded limbs, and hems in marble walls.
—Touch'd by the patriot-flame, he rent amazed
The flimſy bonds, and round and round him gazed;

While ſtern Baſtile. l. 383. "We deſcended with great difficulty into the dungeons, which were made too low for our ſtanding upright; and were ſo dark, that we were obliged at noon-day to viſit them by the light of a candle. We ſaw the hooks of thoſe chains, by which the priſoners were faſtened by their necks to the walls of their cells; many of which being below the level of the water were in a conſtant ſtate of humidity; from which iſſued a noxious vapour, which more than once extinguiſhed the candles. Since the deſtruction of the building many ſubterraneous cells have been diſcovered under a piece of ground, which ſeemed only a bank of ſolid earth before the horrid ſecrets of this priſon-houſe were diſcloſed. Some ſkeletons were found in theſe receſſes with irons ſtill faſtened to their decayed bones." Letters from France, by H. M. Williams. p. 24.

Starts up from earth, above the admiring throng
Lifts his Coloſſal form, and towers along;
High o'er his foes his hundred arms He rears,
Plowſhares his ſwords, and pruning hooks his ſpears;
Calls to the Good and Brave with voice, that rolls
Like Heaven's own thunder round the echoing poles;
Gives to the winds his banner broad unfurl'd,
And gathers in its ſhade the living world!

VII. "Gnomes! you then taught volcanic airs to force
Through bubbling Lavas their reſiſtleſs courſe,
O'er the broad walls of rifted Granite climb,
And pierce the rent roof of incumbent Lime,

And pierce the rent roof. l. 398. The granite rocks and the limeſtone rocks have been cracked to very great depths at the time they were raiſed up by ſubterranean fires; in theſe cracks are found moſt of the metallic ores, except iron and perhaps manganeſe, the former of which is generally found in horizontal ſtrata, and the latter generally near the ſurface of the earth.

Philoſophers poſſeſſing ſo convenient a teſt for the diſcovery of iron by the magnet, have long ſince found it in all vegetable and animal matters; and of late Mr. Scheele has diſcovered the exiſtence of manganeſe in vegetable aſhes. Scheele, 56 mem. Stock. 1774. Kirwan. Min. 353. Which accounts for the production of it near the ſurface of earth, and thence for its calciform appearance, or union with vital air. Bergman has likewiſe ſhewn, that the limeſtones which become bluiſh or dark coloured when calcined,

Round sparry caves metallic lustres fling,
And bear phlogiston on their tepid wing.

possess a mixture of manganese, and are thence preferable as a cement to other kinds of lime. 2. Bergman, 229. Which impregnation with manganese has probably been received from the decomposition of superincumbent vegetable matters.

These cracks or perpendicular caverns in the granite or limestone pass to unknown depths; and it is up these channels that I have endeavoured to shew that the steam rises which becomes afterwards condensed and produces the warm springs of this island, and other parts of the world. (See note on Fucus, Vol. II.) And up these cracks I suppose certain vapours arise, which either alone, or by meeting with something descending into them from above, have produced most of the metals; and several of the materials in which they are bedded. Thus the ponderous earth, Barytes, of Derbyshire, is found in these cracks, and is stratified frequently with lead-ore, and frequently surrounds it. This ponderous earth has been found by Dr. Hoepfner in a granite in Switzerland, and may have thus been sublimed from immense depths by great heat, and have obtained its carbonic or vitriolic acid from above. Annales de Chimie. There is also reason to conclude that something from above is necessary to the formation of many of the metals: at Hawkstone in Shropshire, the seat of Sir Richard Hill, there is an elevated rock of siliceous sand which is coloured green with copper in many places high in the air; and I have in my possession a specimen of lead formed in the cavity of an iron nodule, and another of lead amid spar from a crack of a coal-stratum; all which countenance the modern production of those metals from descending materials. To which should be added, that the highest mountains of granite, which have therefore probably never been covered with marine productions on account of their early elevation, nor with vegetable or animal matters on account of their great coldness, contain no metallic ores, whilst the [illegible] ones contain copper and tin in their cracks or veins, both in Saxony, Silesia, and Cornwall. Kirwan's Mineral. p. 374.

The transmutation of one metal into another, though hitherto undiscovered by the alchymists, does not appear impossible; such transmutations have been supposed to exist in nature, thus lapis calaminaris may have been produced from the destruction of lead-ore, as it is generally found on the top of the veins of lead, where it has been calcined or united with air, and because masses of lead-ore are often found intirely inclosed in it. So silver is found mixed in almost all lead-ores, and sometimes in seperate filaments within the cavities of lead-ore, as I am informed by Mr. Michell, and is thence probably a partial transmutation of the lead to silver, the rapid progress of modern chemistry having shewn the analogy between metallic calces and acids, may lead to the power of transmuting their bases: a discovery much to be wished.

"Hence glows, refulgent Tin! thy chryſtal grains,
And tawny Copper ſhoots her azure veins;
Zinc lines his fretted vault with ſable ore,
And dull Galena teſſellates the floor;
On vermil beds in Idria's mighty caves
The Living Silver rolls its ponderous waves;
With gay refractions bright Platina ſhines,
And ſtuds with ſquander'd ſtars his duſky mines;
Long threads of netted gold, and ſilvery darts,
Inlay the Lazuli, and pierce the Quartz;—
—Whence roof'd with ſilver beam'd Peru, of old,
And hapleſs Mexico was paved with gold.

"Heavens! on my ſight what ſanguine colours blaze!
Spain's deathleſs ſhame! the crimes of modern days!
When Avarice, ſhrouded in Religion's robe,
Sail'd to the Weſt, and ſlaughter'd half the globe;
While Superſtition, ſtalking by his ſide,
Mock'd the loud groans, and lap'd the bloody tide;

For ſacred truths announced her frenzied dreams,
And turn'd to night the ſun's meridian beams.—
Hear, oh, BRITANNIA! potent Queen of iſles,
On whom fair Art, and meek Religion ſmiles,
Now AFRIC's coaſts thy craftier ſons invade
With murder, rapine, theft,—and call it Trade!
—The SLAVE, in chains, on ſupplicating knee,
Spreads his wide arms, and lifts his eyes to Thee;
With hunger pale, with wounds and toil oppreſs'd,
"ARE WE NOT BRETHREN?" ſorrow choaks the reſt;—
—AIR! bear to heaven upon thy azure flood
Their innocent cries!—EARTH! cover not their blood!

VIII. "When Heaven's dread juſtice ſmites in crimes o'ergrown
The blood-nurſed Tyrant on his purple throne,
GNOMES! YOUR bold forms unnumber'd arms outſtretch,
And urge the vengeance o'er the guilty wretch.—

Thus when CAMBYSES led his barbarous hoſts *
From Perſia's rocks to Egypt's trembling coaſts,
Defiled each hallowed fane, and ſacred wood,
And, drunk with fury, ſwell'd the Nile with blood;
Waved his proud banner o'er the Theban ſtates,
And pour'd deſtruction through her hundred gates;
In dread diviſions march'd the marſhal'd bands,
And ſwarming armies blacken'd all the lands,
By Memphis theſe to ETHIOP's ſultry plains,
And thoſe to HAMMON's ſand-incircled fanes.—
Slow as they paſs'd, the indignant temples frown'd,
Low curſes muttering from the vaulted ground;
Long ailes of Cypreſs waved their deepen'd glooms,
And quivering ſpectres grinn'd amid the tombs;
Prophetic whiſpers breathed from SPHINX's tongue,
And MEMNON's lyre with hollow murmurs rung;

* *Thus when Cambyſes.* l. 435. Cambyſes marched one army from Thebes, after having overturned the temples, ravaged the country, and deluged it with blood, to ſubdue Ethiopia; this army almoſt periſhed by famine, inſomuch, that they repeatedly ſlew every tenth man to ſupply the remainder with food. He ſent another army to plunder the temple of Jupiter Ammon, which periſhed overwhelm'd with ſand.

Burſt from each pyramid expiring groans,
And darker ſhadows ſtretch'd their lengthen'd cones.—
Day after day their deathful rout They ſteer,
Luſt in the van, and rapine in the rear.

"Gnomes! as they march'd, You hid the gather'd fruits,
The bladed graſs, ſweet grains, and mealy roots;
Scared the tired quails, that journey'd o'er their heads,
Retain'd the locuſts in their earthy beds;
Bade on your ſands no night-born dews diſtil,
Stay'd with vindictive hands the ſcanty rill.—
Loud o'er the camp the Fiend of Famine ſhrieks,
Calls all her brood, and champs her hundred beaks;
O'er ten ſquare leagues her pennons broad expand,
And twilight ſwims upon the ſhuddering ſand;
Perch'd on her creſt the Griffin Diſcord clings,
And Giant Murder rides between her wings;
Blood from each clotted hair, and horny quill,
And ſhowers of tears in blended ſtreams diſtil;

High-poiſed in air her ſpiry neck ſhe bends,
Rolls her keen eye, her Dragon-claws extends,
Darts from above, and tears at each fell ſwoop
With iron fangs the decimated troop.

"Now o'er their head the whizzing whirlwinds breathe,
And the live deſert pants, and heaves beneath;
Tinged by the crimſon ſun, vaſt columns riſe
Of eddying ſands, and war amid the ſkies,
In red arcades the billowy plain ſurround,
And ſtalking turrets dance upon the ground.
—Long ranks in vain their ſhining blades extend,
To Demon-Gods their knees unhallow'd bend,
Wheel in wide circle, form in hollow ſquare,
And now they front, and now they fly the war,

And ſtalking turrets. l. 478. "At one o'clock we alighted among ſome acacia trees at Waadi el Halboub, having gone twenty-one miles. We were here at once ſurpriſed and terrified by a ſight ſurely one of the moſt magnificent in the world. In that vaſt expanſe of deſert, from W. to N. W. of us, we ſaw a number of prodigious pillars of ſand at different diſtances, at times moving with great celerity, at others ſtalking on with a majeſtic ſlowneſs; at intervals we thought they were coming in a very few minutes to overwhelm us; and ſmall quantities of ſand did actually more than once reach us. Again they would retreat ſo as to be almoſt out of ſight, their tops reaching to the very clouds. There the tops often ſeparated from the bodies; and theſe, once disjoined, diſperſed in the air, and

Pierce the deaf tempeſt with lamenting cries,
Preſs their parch'd lips, and cloſe their blood-ſhot eyes.
—Gnomes! o'er the waſte you led your myriad powers,
Climb'd on the whirls, and aim'd the flinty ſhowers!— 486
Onward reſiſtleſs rolls the infuriate ſurge,
Clouds follow clouds, and mountains mountains urge;
Wave over wave the driving deſert ſwims,
Burſts o'er their heads, inhumes their ſtruggling limbs;

did not appear more. Sometimes they were broken in the middle, as if ſtruck with large cannon-ſhot. About noon they began to advance with conſiderable ſwiftneſs upon us, the wind being very ſtrong at north. Eleven of them ranged along ſide of us about the diſtance of three miles. The greateſt diameter of the largeſt appeared to me at that diſtance as if it would meaſure ten feet. They retired from us with a wind at S.E. leaving an impreſſion upon my mind to which I can give no name, though ſurely one ingredient in it was fear, with a conſiderable deal of wonder and aſtoniſhment. It was in vain to think of flying; the ſwifteſt horſe, or faſteſt ſailing ſhip, could be of no uſe to carry us out of this danger; and the full perſuaſion of this rivetted me as if to the ſpot where I ſtood.

" The ſame appearance of moving pillars of ſand preſented themſelves to us this day in form and diſpoſition like thoſe we had ſeen at Waadi Halboub, only they ſeemed to be more in number and leſs in ſize. They came ſeveral times in a direction cloſe upon us, that is, I believe, within leſs than two miles. They began immediately after ſun riſe like a thick wood and almoſt darkened the ſun. His rays ſhining through them for near an hour, gave them an appearance of pillars of fire. Our people now became deſperate, the Greeks ſhrieked out and ſaid it was the day of judgment; Iſmael pronounced it to be hell; and the Turcorories, that the world was on fire." Bruce's Travels, Vol. IV. p. 553,—555.

From this account it would appear, that the eddies of wind were owing to the long range of broken rocks, which bounded one ſide of the ſandy deſert, and bent the currents of air, which ſtruck againſt their ſides; and were thus like the eddies in a ſtream of water, which falls againſt oblique obſtacles. This explanation is probably the true one, as theſe whirl-winds were not attended with rain or lightening like the tornadoes of the Weſt-Indies.

Man mounts on man, on camels camels ruſh,
Hoſts march o'er hoſts, and nations nations cruſh,—
Wheeling in air the winged iſlands fall,
And one great earthy Ocean covers all!—
Then ceaſed the ſtorm,—NIGHT bow'd his Ethiop brow
To earth, and liſten'd to the groans below,—
Grim HORROR ſhook,—awhile the living hill
Heaved with convulſive throes,—and all was ſtill!

IX. "GNOMES! whoſe fine forms, impaſſive as the air,
Shrink with ſoft ſympathy for human care;
Who glide unſeen, on printleſs ſlippers borne,
Beneath the waving graſs, and nodding corn;
Or lay your tiny limbs, when noon-tide warms,
Where ſhadowy cowſlips ſtretch their golden arms,—
So mark'd on orreries in lucid ſigns,
Star'd with bright points the mimic zodiac ſhines;

So mark'd on orreries. l. 505. The firſt orrery was conſtructed by a Mr. Rowley, a mathematician born at Lichfield; and ſo named from his patron the Earl of Orrery. Johnſon's Dictionary.

Borne on fine wires amid the pictured ſkies
With ivory orbs the planets ſet and riſe;
Round the dwarf earth the pearly moon is roll'd,
And the ſun twinkling whirls his rays of gold.—
Call your bright myriads, march your mailed hoſts,
With ſpears and helmets glittering round the coaſts;
Thick as the hairs, which rear the Lion's mane,
Or fringe the Boar, that bays the hunter-train;
Watch, where proud Surges break their treacherous mounds,
And ſweep reſiſtleſs o'er the cultured grounds;
Such as erewhile, impell'd o'er Belgia's plain,
Roll'd her rich ruins to the inſatiate main;
With piles and piers the ruffian waves engage,
And bid indignant Ocean ſtay his rage.

"Where, girt with clouds, the rifted mountain yawns,
And chills with length of ſhade the gelid lawns,

Climb the rude ſteeps, the granite-cliffs ſurround,
Pierce with ſteel points, with wooden wedges wound;
Break into clays the ſoft volcanic ſlaggs,
Or melt with acid airs the marble craggs;
Crown the green ſummits with adventurous flocks,
And charm with novel flowers the wondering rocks.
—So when proud Rome the Afric Warrior braved,
And high on Alps his crimſon banner waved;
While rocks on rocks their beetling brows oppoſe
With piny foreſts, and unfathomed ſnows;

The granite-cliffs. l. 523. On long expoſure to air the granites or porphories of this country exhibit a ferrugenous cruſt, the iron being calcined by the air firſt becomes viſible, and is then waſhed away from the external ſurface, which becomes white or grey, and thus in time ſeems to decompoſe. The marbles ſeem to decompoſe by looſing their carbonic acid, as the outſide, which has been long expoſed to the air, does not ſeem to effervеſce ſo haſtily with acids as the parts more recently broken. The immenſe quantity of carbonic acid, which exiſts in the many provinces of lime-ſtone, if it was extricated and decompoſed would afford charcoal enough for fuel for ages, or for the production of new vegetable or animal bodies. The volcanic ſlaggs on Mount Veſuvius are ſaid by M. Ferber to be changed into clay by means of the ſulphur-acid, and even pots made of clay and burnt or vitrified are ſaid by him to be again reducible to ductile clay by the volcanic ſteams. Ferber's Travels through Italy, p. 166.

Wooden wedges wound. l. 524. It is uſual in ſeperating large mill-ſtones from the ſiliceous ſand-rocks in ſome parts of Derbyſhire to bore horizontal holes under them in a circle, and fill theſe with pegs made of dry wood, which gradually ſwell by the moiſture of the earth, and in a day or two lift up the mill-ſtone without breaking it.

Onward he march'd, to Latium's velvet ground
With fires and acids burſt the obdurate bound,
Wide o'er her weeping vales deſtruction hurl'd,
And ſhook the riſing empire of the world.

X. " Go, gentle Gnomes! reſume your vernal toil,
Seek my chill tribes, which ſleep beneath the ſoil;
On grey-moſs banks, green meads, or furrow'd lands
Spread the dark mould, white lime, and crumbling ſands;
Each burſting bud with healthier juices feed,
Emerging ſcion, or awaken'd ſeed.
So, in deſcending ſtreams, the ſilver Chyle
Streaks with white clouds the golden floods of bile;

With fires and acids. l. 539. Hannibal was ſaid to erode his way over the Alps by fire and vinegar. The latter is ſuppoſed to allude to the vinegar and water which was the beverage of his army. In reſpect to the former it is not improbable, but where wood was to be had in great abundance, that fires made round lime-ſtone precipices would calcine them to a conſiderable depth, the night-dews or mountain-miſts would penetrate theſe calcined parts and pulverize them by the force of the ſteam which the generated heat would produce, the winds would diſperſe this lime-powder, and thus by repeated fires a precipice of lime-ſtone might be deſtroyed and a paſſage opened. It ſhould be added, that according to Ferber's obſervations, theſe Alps conſiſt of lime-ſtone. Letters from Italy.

Through each nice valve the mingling currents glide,
Join their fine rills, and ſwell the ſanguine tide;
Each countleſs cell, and viewleſs fibre ſeek,
Nerve the ſtrong arm, and tinge the bluſhing cheek.

"Oh, watch, where boſom'd in the teeming earth,
Green ſwells the germ, impatient for its birth;
Guard from rapacious worms its tender ſhoots,
And drive the mining beetle from its roots;
With ceaſeleſs efforts rend the obdurate clay,
And give my vegetable babes to day!
—Thus when an Angel-form, in light array'd,
Like HOWARD pierced the priſon's noiſome ſhade;
Where chain'd to earth, with eyes to heaven upturn'd,
The kneeling Saint in holy anguiſh mourn'd;—
Ray'd from his lucid veſt, and halo'd brow
O'er the dark roof celeſtial luſtres glow,
"PETER, ariſe!" with cheering voice He calls,
And ſounds ſeraphic echo round the walls;

Locks, bolts, and chains his potent touch obey,
And pleaſed he leads the dazzled Sage to day.

XI. "You! whoſe fine fingers fill the organic cells,
With virgin earth, of woods and bones and ſhells;
Mould with retractile glue their ſpongy beds,
And ſtretch and ſtrengthen all their fibre-threads.—
Late when the maſs obeys its changeful doom,
And ſinks to earth, its cradle and its tomb,
Gnomes! with nice eye the ſlow ſolution watch,
With foſtering hand the parting atoms catch,

Mould with retractile glue. l. 577. The conſtituent parts of animal fibres are believed to be earth and gluten. Theſe do not ſeperate except by long putrefaction or by fire. The earth then effervеſces with acids, and can only be converted into glaſs by the greateſt force of fire. The gluten has continued united with the earth of the bones above 2000 years in Egyptian mummies; but by long expoſure to air or moiſture it diſſolves and leaves only the earth. Hence bones long buried, when expoſed to the air, abſorb moiſture and crumble into powder. Phil. Tranſ. No. 475. The retractibility or elaſticity of the animal fibre depends on the gluten; and of theſe fibres are compoſed the membranes muſcles and bones. Haller. Phyſiol. Tom. I. p. 2.

For the chemical decompoſition of animal and vegetable bodies ſee the ingenious work of Lavoiſier, Traité de Chimie, Tom. I. p. 132. who reſolves all their component parts into oxygene, hydrogene, carbone, and azote, the three former of which belong principally to vegetable and the laſt to animal matter.

Join in new forms, combine with life and ſenſe,
And guide and guard the tranſmigrating Ens.

" So when on Lebanon's ſequeſter'd hight
The fair ADONIS left the realms of light,

The tranſmigrating Ens. l. 584. The perpetual circulation of matter in the growth and diſſolution of vegetable and animal bodies ſeems to have given Pythagoras his idea of the metempſycoſis or tranſmigration of ſpirit; which was afterwards dreſſed out or ridiculed in variety of amuſing fables. Other philoſophers have ſuppoſed, that there are two different materials or eſſences, which fill the univerſe. One of theſe, which has the power of commencing or producing motion, is called ſpirit; the other, which has the power of receiving and of communicating motion, but not of beginning it, is called matter. The former of theſe is ſuppoſed to be diffuſed through all ſpace, filling up the interſtices of the ſuns and planets, and conſtituting the gravitations of the ſidereal bodies, the attractions of chemiſtry, with the ſpirit of vegetation, and of animation. The latter occupies comparatively but ſmall ſpace, conſtituting the ſolid parts of the ſuns and planets, and their atmoſpheres. Hence theſe philoſophers have ſuppoſed, that both matter and ſpirit are equally immortal and unperiſhable; and that on the diſſolution of vegetable or animal organization, the matter returns to the general maſs of matter; and the ſpirit to the general maſs of ſpirit, to enter again into new combinations, according to the original idea of Pythagoras.

The ſmall apparent quantity of matter that exiſts in the univerſe compared to that of ſpirit, and the ſhort time in which the recrements of animal or vegetable bodies become again vivified in the forms of vegetable mucor or microſcopic inſects, ſeems to have given riſe to another curious fable of antiquity. That Jupiter threw down a large handful of ſouls upon the earth, and left them to ſcramble for the few bodies which were to be had.

Adonis. l. 586. The very antient ſtory of the beautiful Adonis paſſing one half of the year with Venus, and the other with Proſerpine alternately, has had variety of interpretations. Some have ſuppoſed that it allegorized the ſummer and winter ſolſtice; but this ſeems too obvious a fact to have needed an hieroglyphic emblem. Others have believed it to repreſent the corn, which was ſuppoſed to ſleep in the earth during the

Bow'd his bright locks, and, fated from his birth
To change eternal, mingled with the earth;—
With darker horror ſhook the conſcious wood,
Groan'd the ſad gales, and rivers bluſh'd with blood;
On cypreſs-boughs the Loves their quivers hung,
Their arrows ſcatter'd, and their bows unſtrung;
And Beauty's Goddess, bending o'er his bier,
Breathed the ſoft ſigh, and pour'd the tender tear.—
Admiring Proserpine through duſky glades
Led the fair phantom to Elyſian ſhades,
Clad with new form, with finer ſenſe combined,
And lit with purer flame the ethereal mind.

winter months, and to riſe out of it in ſummer. This does not accord with the climate of Egypt, where the harveſt ſoon follows the ſeed-time.

It ſeems more probably to have been a ſtory explaining ſome hieroglyphic figures repreſenting the decompoſition and reſuſcitation of animal matter; a ſublime and intereſting ſubject, and which ſeems to have given origin to the doctrine of the tranſmigration, which had probably its birth alſo from the hieroglyphic treaſures of Egypt. It is remarkable that the cypreſs groves in the antient greek writers, as in Theocritus, were dedicated to Venus; and afterwards became funereal emblems. Which was probably occaſioned by the Cypreſs being an accompaniment of Venus in the annual proceſſions, in which ſhe was ſuppoſed to lament over the funeral of Adonis; a ceremony which obtained over all the eaſtern world from great antiquity, and is ſuppoſed to be referred to by Ezekiel, who accuſes the idolatrous woman of weeping for Thammus.

—Erewhile, emerging from infernal night,
The bright Aſſurgent riſes into light,
Leaves the drear chambers of the inſatiate tomb,
And ſhines and charms with renovated bloom.—
While wondering Loves the burſting grave ſurround,
And edge with meeting wings the yawning ground,
Stretch their fair necks, and leaning o'er the brink
View the pale regions of the dead, and ſhrink;
Long with broad eyes ecſtatic BEAUTY ſtands,
Heaves her white boſom, ſpreads her waxen hands;
Then with loud ſhriek the panting Youth alarms,
"My Life! my Love!" and ſprings into his arms."

The GODDESS ceaſed,—the delegated throng
O'er the wide plains delighted ruſh along;
In duſky ſquadrons, and in ſhining groups,
Hoſts follow hoſts, and troops ſucceed to troops;
Scarce bears the bending graſs the moving freight,
And nodding florets bow beneath their weight.

So when light clouds on airy pinions ſail,
Flit the ſoft ſhadows o'er the waving vale;
Shade follows ſhade, as laughing Zephyrs drive,
And all the chequer'd landſcape ſeems alive.

Zephyrs drive. l. 619. Theſe lines were originally written thus,

Shade follows ſhade by laughing Zephyrs drove,
And all the chequer'd landſcape ſeems to move.

but were altered on account of the ſuppoſed falſe grammar in uſing the word drove for driven, according to the opinion of Dr. Lowth: at the ſame time it may be obſerved, 1. that this is in many caſes only an ellipſis of the letter *n* at the end of the word; as froze, for frozen; wove, for woven; ſpoke, for ſpoken; and that then the participle accidentally becomes ſimilar to the paſt tenſe: 2. that the language ſeems gradually tending to omit the letter *n* in other kind of words for the ſake of euphony; as houſen is become houſes; eyne, eyes; thine, thy, &c. and in common converſation, the words forgot, ſpoke, froze, rode, are frequently uſed for forgotten, ſpoken, frozen, ridden. 3. It does not appear that any confuſion would follow the indiſcriminate uſe of the ſame word for the paſt tenſe and the participle paſſive, ſince the auxillary verb *have*, or the preceding noun or pronoun always clearly diſtinguiſhes them: and laſtly, rhime-poetry muſt loſe the uſe of many elegant words without this licenſe.

Argument of the Third Canto.

ADDRESS to the Nymphs. I. Steam rifes from the ocean, floats in clouds, defcends in rain and dew, or is condenfed on hills, produces fprings, and rivers, and returns to the fea. So the blood circulates through the body and returns to the heart. 11. II. 1. Tides, 57. 2. Echinus, nautilus, pinna, cancer. Grotto of a mermaid. 65. 3. Oil ftills the waves. Coral rocks. Ship-worm, or Teredo. Maelftrome, a whirlpool on the coaft of Norway. 85. III. Rivers from beneath the fnows on the Alps. The Tiber. 103. IV. Overflowing of the Nile from African Monfoons, 129. V. 1. Giefar, a boiling fountain in Iceland, deftroyed by inundation, and confequent earthquake, 145. 2. Warm medicinal fprings. Buxton. Duke and Dutchefs of Devonfhire. 157. VI. Combination of vital air and inflammable gas produces water. Which is another fource of fprings and rivers. Allegorical loves of Jupiter and Juno productive of vernal fhowers. 201. VII. Aquatic Tafte. Diftant murmur of the fea by night. Sea-horfe. Nereid finging. 261. VIII. The Nymphs of the river Derwent lament the death of Mrs. French, 297. IX. Inland navigation. Monument for Mr. Brindley, 321. X. Pumps explained. Child fucking. Mothers exhorted to nurfe their children. Cherub fleeping. 345. XI. Engines for extinguifhing fire. Story of two lovers perifhing in the flames. 377. XII. Charities of Mifs Jones, 427.

XIII. Marſhes drained. Hercules conquers Achilous. The horn of Plenty. 463. XIV. Showers. Dews. Floating lands with water. Lacteal ſyſtem in animals. Caravan drinking. 509. Departure of the Nymphs like water ſpiders; like northern nations ſkaiting on the ice. 549.

THE

ECONOMY OF VEGETATION.

CANTO III.

AGAIN the GODDESS ſpeaks!—glad Echo ſwells
The tuneful tones along her ſhadowy dells,
Her wrinkling founts with ſoft vibration ſhakes,
Curls her deep wells, and rimples all her lakes,
Thrills each wide ſtream, Britannia's iſle that laves,
Her headlong cataracts, and circumfluent waves.

—Thick as the dews, which deck the morning flowers,
Or rain-drops twinkling in the ſun-bright ſhowers,
Fair Nymphs, emerging in pellucid bands,
Riſe, as ſhe turns, and whiten all the lands.

I. " YOUR buoyant troops on dimpling ocean tread,
Waſting the moiſt air from his oozy bed,
AQUATIC NYMPHS !—YOU lead with viewleſs march
The winged vapours up the aerial arch,
On each broad cloud a thouſand ſails expand,
And ſteer the ſhadowy treaſure o'er the land,

The winged vapours. l. 14. See additional note No. XXV. on evaporation.

On each broad cloud. l. 15. The clouds conſiſt of condenſed vapour, the particles of which are too ſmall ſeparately to overcome the tenacity of the air, and which therefore do not deſcend. They are in ſuch ſmall ſpheres as to repel each other, that is, they are applied to each other by ſuch very ſmall ſurfaces, that the attraction of the particles of each drop to its own centre is greater than its attraction to the ſurface of the drop in its vicinity; every one has obſerved with what difficulty ſmall ſpherules of quickſilver can be made to unite, owing to the ſame cauſe; and it is common to ſee on riding through ſhallow water on a clear day, numbers of very ſmall ſpheres of water as they are thrown from the horſes feet run along the ſurface for many yards before they again unite with it. In many caſes theſe ſpherules of water, which compoſe clouds, are kept from uniting by a ſurplus of electric fluid; and fall in violent ſhowers as ſoon as that is withdrawn from them, as in thunder ſtorms. See note on Canto I. l. 554.

If in this ſtate a cloud becomes frozen, it is torn to pieces in its deſcent by the friction of the air, and falls in white flakes of ſnow. Or theſe flakes are rounded by being rubbed

Through vernal ſkies the gathering drops diffuſe,
Plunge in ſoſt rains, or ſink in ſilver dews.—

together by the winds, and by having their angles thawed off by the warmer air beneath as they deſcend; and part of the water produced by theſe angles thus diſſolved is abſorbed into the body of the hailſtone, as may be ſeen by holding a lump of ſnow over a candle, and there becomes frozen into ice by the quantity of cold which the hailſtone poſſeſſes beneath the freezing point, or which is produced by its quick evaporation in falling; and thus hailſtones are often found of greater or leſs denſity according as they conſiſt of a greater portion of ſnow or ice. If hailſtones conſiſted of the large drops of ſhowers frozen in their deſcent, they would conſiſt of pure tranſparent ice.

As hail is only produced in ſummer, and is always attended with ſtorms, ſome philoſophers have believed that the ſudden departure of electricity from a cloud may effect ſomething yet unknown in this phenomenon; but it may happen in ſummer independent of electricity, becauſe the aqueous vapour is then raiſed higher in the atmoſphere, whence it has further to fall, and there is warmer air below for it to fall through.

Or ſink in ſilver dews. l. 18. During the coldneſs of the night the moiſture before diſſolved in the air is gradually precipitated, and as it ſubſides adheres to the bodies it falls upon. Where the attraction of the body to the particles of water is greater than the attractions of thoſe particles to each other, it becomes ſpread upon their ſurface, or ſlides down them in actual contact; as on the broad parts of the blades of moiſt graſs: where the attraction of the ſurface to the water is leſs than the attraction of the particles of water to each other, the dew ſtands in drops; as on the points and edges of graſs or gorſe, where the ſurface preſented to the drop being ſmall it attracts it ſo little as but juſt to ſupport it without much changing its globular form: where there is no attraction between the vegetable ſurface and the dew drops, as on cabbage leaves, the drop does not come into contact with the leaf, but hangs over it repelled, and retains it natural form, compoſed of the attraction and preſſure of its own parts, and thence looks like quickſilver, reflecting light from both its ſurfaces. Nor is this owing to any oilineſs of the leaf, but ſimply to the poliſh of its ſurface, as a light needle may be laid on water in the ſame manner without touching it; for as the attractive powers of poliſhed ſurfaces are greater when in actual contact, ſo the repulſive power is greater before contact.

YOUR lucid bands condenſe with fingers chill
The blue miſt hovering round the gelid hill;
In clay-form'd beds the trickling ſtreams collect,
Strain through white ſands, through pebbly veins direct;
Or point in rifted rocks their dubious way,
And in each bubbling fountain riſe to day.

The blue miſt. l. 20. Miſts are clouds reſting on the ground, they generally come on at the beginning of night, and either fill the moiſt vallies, or hang on the ſummits of hills, according to the degree of moiſture previouſly diſſolved, and the eduction of heat from them. The air over rivers during the warmth of the day ſuſpends much moiſture, and as the changeful ſurface of rivers occaſions them to cool ſooner than the land at the approach of evening, miſts are moſt frequently ſeen to begin over rivers, and to ſpread themſelves over moiſt grounds, and fill the vallies, while the miſts on the tops of mountains are more properly clouds, condenſed by the coldneſs of their ſituation.

On aſcending up the ſide of a hill from a miſty valley, I have obſerved a beautiful coloured halo round the moon when a certain thickneſs of miſt was over me, which ceaſed to be viſible as ſoon as I emerged out of it; and well remember admiring with other ſpectators the ſhadow of the three ſpires of the cathedral church at Lichfield, the moon riſing behind it, apparently broken off, and lying diſtinctly over our heads as if horizontally on the ſurface of the miſt, which aroſe about as high as the roof of the church. There are ſome curious remarks on ſhadows or reflections ſeen on the ſurface of miſts from high mountains in Ulloa's Voyages. The dry miſt of ſummer 1783, was probably occaſioned by volcanic eruption, as mentioned in note on Chunda, Vol. II. and therefore more like the atmoſphere of ſmoke which hangs on ſtill days over great cities.

There is a dry miſt, or rather a diminiſhed tranſparence of the air, which according to Mr. Sauſſure accompanies fair weather, while great tranſparence of air indicates rain. Thus when large rivers two miles broad, ſuch as at Liverpool, appear narrow, it is ſaid to prognoſticate rain; and when wide, fair weather. This want of tranſparence of the air in dry weather, may be owing to new combinations or decompoſitions of the vapours diſſolved in it, but wants further inveſtigation. Eſſais ſur L'Hygromet, p. 357.

Round the gelid hill. l. 20. See additional notes, No. XXVI. on the origin of ſprings.

"Nymphs! you then guide, attendant from their ſource,
The aſſociate rills along their ſinuous courſe;
Float in bright ſquadrons by the willowy brink,
Or circling ſlow in limpid eddies ſink;
Call from her cryſtal cave the Naiad-Nymph,
Who hides her fine form in the paſſing lymph,
And, as below ſhe braids her hyaline hair,
Eyes her ſoft ſmiles reflected in the air;
Or ſport in groups with River-Boys, that lave
Their ſilken limbs amid the daſhing wave;
Pluck the pale primroſe bending from its edge,
Or tittering dance amid the whiſpering ſedge.—

"Onward you paſs, the pine-capt hills divide,
Or feed the golden harveſts on their ſide;
The wide-ribb'd arch with hurrying torrents fill,
Shove the ſlow barge, or whirl the foaming mill.
Or lead with beckoning hand the ſparkling train
Of refluent water to its parent main,

And pleaſed reviſit in their ſea-moſs vales
Blue Nereid-forms array'd in ſhining ſcales,
Shapes, whoſe broad oar the torpid wave impels,
And Tritons bellowing through their twiſted ſhells.

"So from the heart the ſanguine ſtream diſtils,
O'er Beauty's radiant ſhrine in vermil rills,
Feeds each fine nerve, each ſlender hair pervades,
The ſkins bright ſnow with living purple ſhades,
Each dimpling cheek with warmer bluſhes dyes,
Laughs on the lips, and lightens in the eyes.
—Erewhile abſorb'd, the vagrant globules ſwim
From each fair feature, and proportion'd limb,
Join'd in one trunk with deeper tint return
To the warm concave of the vital urn.

II. I. "AQUATIC MAIDS! YOU ſway the mighty realms
Of ſcale and ſhell, which Ocean overwhelms;
As Night's pale Queen her riſing orb reveals,
And climbs the zenith with refulgent wheels,

Car'd on the foam your glimmering legion rides,
Your little tridents heave the dashing tides,
Urge on the sounding shores their crystal course,
Restrain their fury, or direct their force.

Car'd on the foam. l. 61. The phenomena of the tides have been well investigated and satisfactorily explained by Sir Isaac Newton and Dr. Halley from the reciprocal gravitations of the earth, moon, and sun. As the earth and moon move round a centre of motion near the earth's surface, at the same time that they are proceeding in their annual orbit round the sun, it follows that the water on the side of the earth nearest this centre of motion between the earth and moon will be more attracted by the moon, and the waters on the opposite side of the earth will be less attracted by the moon, than the central parts of the earth. Add to this that the centrifugal force of the water on the side of the earth furthest from the centre of the motion, round which the earth and moon move, (which, as was said before, is near the surface of the earth) is greater than that on the opposite side of the earth, From both these causes it is easy to comprehend that the water will rise on two sides of the earth, viz. on that nearest to the moon, and its opposite side, and that it will be flattened in consequence at the quadratures, and thus produce two tides in every lunar day, which consists of about twenty-four hours and forty-eight minutes.

These tides will be also affected by the solar attraction when it coincides with the lunar one, or opposes it, as at new and full moon, and will also be much influenced by the opposing shores in every part of the earth.

Now as the moon in moving round the centre of gravity between itself and the earth describes a much larger orbit than the earth describes round the same centre, it follows that the centrifugal motion on the side of the moon opposite to the earth must be much greater than the centrifugal motion of the side of the earth opposite to the moon round the same centre, And secondly, as the attraction of the earth exerted on the moon's surface next to the earth is much greater than the attraction of the moon exerted on the earth's surface, the tides on the lunar sea, (if such there be,) should be much greater than those of our ocean. Add to this that as the same face of the moon always is turned to the earth, the lunar tides must be permanent, and if the solid parts of the moon be spherical, must always cover the phasis next to us. But as there are evidently hills and vales and volcanos on this side of the moon, the consequence is that the moon has no ocean, or that it is frozen.

2. "NYMPHS! YOU adorn, in gloſſy volumes roll'd,
The gaudy conch with azure, green, and gold. 66
You round Echinus ray his arrowy mail,
Give the keel'd Nautilus his oar and ſail;

The gaudy conch. l. 66. The ſpiral form of many ſhells ſeem to have afforded a more frugal manner of covering the long tail of the fiſh with calcareous armour; ſince a ſingle thin partition between the adjoining circles of the fiſh was ſufficient to defend both ſurfaces, and thus much cretaceous matter is ſaved; and it is probable that from this ſpiral form they are better enabled to feel the vibrations of the element in which they exiſt. See note on Canto IV. l. 162. This cretaceous matter is formed by a mucous ſecretion from the ſkin of the fiſh, as is ſeen in crab-fiſh, and others which annually caſt their ſhells, and is at firſt a ſoft mucous covering, (like that of a hen's egg, when it is laid a day or two too ſoon,) and which gradually hardens. This may alſo be ſeen in common ſhell ſnails, if a part of their ſhell be broken it becomes repaired in a ſimilar manner with mucus, which by degrees hardens into ſhell.

It it probable the calculi or ſtones found in other animals may have a ſimilar origin, as they are formed on mucous membranes, as thoſe of the kidney and bladder, chalk-ſtones in the gout, and gall-ſtones; and are probably owing to the inflammation of the membrane where they are produced, and vary according to the degree of inflammation of the membrane which forms them, and the kind of mucous which it naturally produces. Thus the ſhelly matter of different ſhell-fiſh differs, from the courſer kinds which form the ſhells of crabs, to the finer kinds which produces the mother-pearl.

The beautiful colours of ſome ſhells originate from the thinneſs of the laminæ of which they conſiſt, rather than to any colouring matter, as is ſeen in mother-pearl, which reflects different colours according to the obliquity of the light which falls on it. The beautiful priſmatic colours ſeen on the Labrodore ſtone are owing to a ſimilar cauſe, viz. the thinneſs of the laminæ of which it conſiſts, and has probably been formed from mother-pearl ſhells.

It is curious that ſome of the moſt common foſſil ſhells are not now known in their recent ſtate, as the cornua ammonis; and on the contrary, many ſhells which are very plentiful in their recent ſtate, as limpets, ſea-ears, volutes, cowries, are very rarely found foſſil. Da Coſta's Conchology, p. 163. Were all the ammoniæ deſtroyed when the continents were raiſed? Or do ſome genera of animals periſh by the increaſing power of their enemies? Or do they ſtill reſide at inacceſſible depths in the ſea? Or do ſome animals change their forms gradually and become new genera?

Echinus. Nautilus. l. 67, 68. See additional notes, No. XXVII.

Firm to his rock with ſilver cords ſuſpend
The anchor'd Pinna, and his Cancer-friend;
With worm-like beard his toothleſs lips array,
And teach the unwieldy Sturgeon to betray.—
Ambuſh'd in weeds, or ſepulcher'd in ſands,
In dread repoſe He waits the ſcaly bands,
Waves in red ſpires the living lures, and draws
The unwary plunderers to his circling jaws,
Eyes with grim joy the twinkling ſhoals beſet,
And claſps the quick inextricable net.
You chaſe the warrior Shark, and cumberous Whale,
And guard the Mermaid in her briny vale;
Feed the live petals of her inſect-flowers,
Her ſhell-wrack gardens, and her ſea-fan bowers;

Pinna. Cancer. l. 70. See additional notes, No. XXVII.

With worm-like beard. l. 71. See additional notes, No. XXVIII.

Feed the live petals. l. 82. There is a ſea-inſect deſcribed by Mr. Huges whoſe claws or tentacles being diſpoſed in regular circles and tinged with variety of bright lively colours repreſent the petals of ſome moſt elegantly fringed and radiated flowers as the carnation, marigold, and anemone. Philoſ. Tranſ. Abridg. Vol. IX. p. 110. The Abbe Dicquemarre has further elucidated the hiſtory of the actinia; and obſerved their manner

With ores and gems adorn her coral cell,
And drop a pearl in every gaping ſhell.

3. "Your myriad trains o'er ſtagnant ocean's tow,
Harneſs'd with goſſamer, the loitering prow;
Or with fine films, ſuſpended o'er the deep,
Of oil effuſive lull the waves to ſleep.
You ſtay the flying bark, conceal'd beneath,
Where living rocks of worm-built coral breathe;

of taking their prey by incloſing it in theſe beautiful rays like a net. Phil. Tranſ. Vol LXIII. and LXV. and LXVII.

And drop a pearl. l. 84. Many are the opinions both of antient and modern writers concerning the production of pearls. Mr. Reaumur thinks they are formed like the hard concretions in many land animals as ſtones of the bladder, gall-ſtones, and bezoar, and hence concludes them to be a diſeaſe of the fiſh, but there ſeems to be a ſtricter analogy between theſe and the calcareous productions found in crab-fiſh called crab's eyes, which are formed near the ſtomach of the animal, and conſtitute a reſervoir of calcareous matter againſt the renovation of the ſhell, at which time they are re-diſſolved and depoſited for that purpoſe. As the internal part of the ſhell of the pearl oyſter or muſcle conſiſts of mother-pearl which is a ſimilar material to the pearl and as the animal has annually occaſion to enlarge his ſhell there is reaſon to ſuſpect the looſe pearls are ſimilar reſervoirs of the pearly matter for that purpoſe.

Or with fine films. l. 87. See additional notes, No. XXIX.

Where living rocks. l. 90. The immenſe and dangerous rocks built by the ſwarms of coral inſects which riſe almoſt perpendicularly in the ſouthern ocean like walls are

Meet fell TEREDO, as he mines the kee
With beaked head, and break his lips of ſteel;
Turn the broad helm, the fluttering canvas urge
From MAELSTROME's fierce innavigable ſurge.
—'Mid the lorn iſles of Norway's ſtormy main,
As ſweeps o'er many a league his eddying train,
Vaſt watery walls in rapid circles ſpin,
And deep-ingulph'd the Demon dwells within;
Springs o'er the fear-froze crew with Harpy-claws,
Down his deep den the whirling veſſel draws;
Churns with his bloody mouth the dread repaſt,
The booming waters murmuring o'er the maſt.

deſcribed in Cook's voyages, a point of one of theſe rocks broke off and ſtuck in the hole which it had made in the bottom of one of his ſhips, which would otherwiſe have periſhed by the admiſſion of water. The numerous lime-ſtone rocks which conſiſt of a congeries of the cells of theſe animals and which conſtitute a great part of the ſolid earth ſhew their prodigious multiplication in all ages of the world. Specimens of theſe rocks are to be ſeen in the Lime-works at Linſel near Newport in Shropſhire, in Coal-brook Dale, and in many parts of the Peak of Derbyſhire. The inſect has been well deſcribed by M. Peyſſonnel, Ellis, and others. Phil. Tranſ. Vol. XLVII. L. LII. and LVII.

Meet fell Teredo. l. 91. See additional notes, No. XXX.

Turn the broad helm. l. 93. See additional notes, No. XXXI.

III. "Where with chill frown enormous Alps alarms
A thouſand realms, horizon'd in his arms;
While cloudleſs ſuns meridian glories ſhed
From ſkies of ſilver round his hoary head,
Tall rocks of ice refract the coloured rays,
And Froſt ſits throned amid the lambent blaze;
Nymphs! your thin forms pervade his glittering piles,
His roofs of chryſtal, and his glaſſy ailes;
Where in cold caves impriſoned Naiads ſleep,
Or chain'd on moſſy couches wake and weep;
Where round dark crags indignant waters bend
Through rifted ice, in ivory veins deſcend,
Seek through unfathom'd ſnows their devious track,
Heave the vaſt ſpars, the ribbed granites crack,

Where round dark craggs. l. 113. See additional notes, No. XXXII.

Heave the vaſt ſpars. l. 116. Water in deſcending down elevated ſituations if the outlet for it below is not ſufficient for its emiſſion acts with a force equal to the height of the column, as is ſeen in an experimental machine called the philoſophical bellows, in which a few pints of water are made to raiſe many hundred pounds. To this cauſe is to be aſcribed many large promontories of ice being occaſionally thrown down from the glaciers; rocks have likewiſe been thrown from the ſides of mountains by the ſame

Ruſh into day, in foamy torrents ſhine,
And ſwell the imperial Danube or the Rhine.—
—Or feed the murmuring TIBER, as he laves
His realms inglorious with diminiſh'd waves,
Hears his lorn Forum ſound with Eunuch-ſtrains,
Sees dancing ſlaves inſult his martial plains;

cauſe, and large portions of earth have been removed many hundred yards from their ſituations at the foot of mountains. On inſpecting the locomotion of about thirty acres of earth with a ſmall houſe near Bilder's Bridge in Shropſhire, about twenty years ago, from the foot of a mountain towards the river, I well remember it bore all the marks of having been thus lifted up, puſhed away, and as it were crumpled into ridges, by a column of water contained in the mountain.

From water being thus confined in high columns between the ſtrata of mountainous countries it has often happened that when wells or perforations have been made into the earth, that ſprings have ariſen much above the ſurface of the new well. When the new bridge was building at Dublin Mr. G. Semple found a ſpring in the bed of the river where he meant to lay the foundation of a pierre, which, by fixing iron pipes into it, he raiſed many feet. Treatiſe on Building in Water, by G. Semple. From having obſerved a valley north-weſt of St. Alkmond's well near Derby, at the head of which that ſpring of water once probably exiſted, and by its current formed the valley, (but which in after times found its way out in its preſent ſituation,) I ſuſpect that St. Alkmond's well might by building round it be raiſed high enough to ſupply many ſtreets in Derby with ſpring-water which are now only ſupplied with river-water. See an account of an artificial ſpring of water, Phil. Tranſ. Vol. LXXV. p. 1.

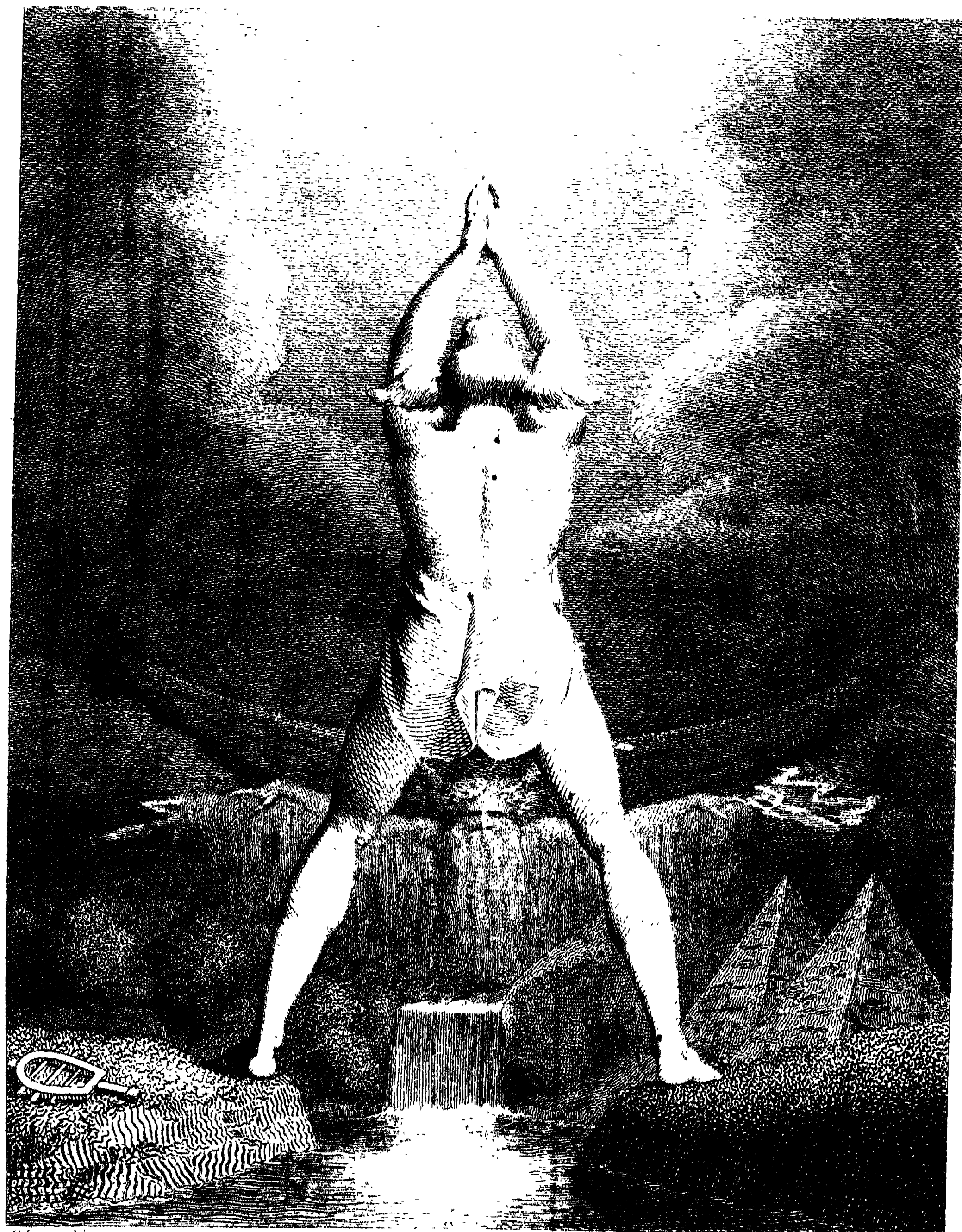
In making a well at Sheerneſs the water roſe 300 feet above its ſource in the well. Phil. Tranſ. Vol. LXXIV. And at Hartford in Connecticut there is a well which was dug ſeventy feet deep before water was found, then in boring an augur-hole through a rock the water roſe ſo faſt as to make it difficult to keep it dry by pumps till they could blow the hole larger by gunpowder, which was no ſooner accompliſhed than it filled and run over, and has been a brook for near a century. Travels through America. Lond. 1789. Lane.

Parts with chill ſtream the dim religious bower,
Time-mouldered baſtion, and diſmantled tower;
By alter'd fanes and nameleſs villas glides,
And claſſic domes, that tremble on his ſides;
Sighs o'er each broken urn, and yawning tomb,
And mourns the fall of LIBERTY and ROME.

IV. "Sailing in air, when dark MONSOON inſhrouds
His tropic mountains in a night of clouds;
Or drawn by whirlwinds from the Line returns,
And ſhowers o'er Afric all his thouſand urns;

Dark monſoon inſhrouds. l. 129. When from any peculiar ſituations of land in reſpect to ſea the tropic becomes more heated, when the ſun is vertical over it, than the line, the periodical winds called monſoons are produced, and theſe are attended by rainy ſeaſons; for as the air at the tropic is now more heated than at the line it aſcends by decreaſe of its ſpecific gravity, and floods of air ruſh in both from the South Weſt and North Eaſt, and theſe being one warmer than the other the rain is precipitated by their mixture as obſerved by Dr. Hutton. See additional notes, No. XXV. All late travellers have aſcribed the riſe of the Nile to the monſoons which deluge Nubia and Abyſſinia with rain. The whirling of the aſcending air was even ſeen by Mr. Bruce in Abyſſinia; he ſays, "every morning a ſmall cloud began to whirl round, and preſently after the whole "heavens became covered with clouds," by this vortex of aſcending air the N. E. winds and the S. W. winds, which flow in to ſupply the place of the aſcending column, became mixed more rapidly and depoſited their rain in greater abundance.

Mr. Volney obſerves that the time of the riſing of the Nile commences about the 19th of June, and that Abyſſinia and the adjacent parts of Africa are deluged with rain



Fertilization of Egypt

High o'er his head the beams of SIRIUS glow,
And, Dog of Nile, ANUBIS barks below.
NYMPHS! YOU from cliff to cliff attendant guide
In headlong cataracts the impetuous tide;
Or lead o'er wastes of Abyssinian sands
The bright expanse to EGYPT's shower-less lands.
—Her long canals the sacred waters fill,
And edge with silver every peopled hill;

in May, June, and July, and produce a mass of water which is three months in draining off. The Abbe Le Pluche observes that as Sirius, or the dog-star, rose at the time of the commencement of the flood its rising was watched by the astronomers, and notice given of the approach of inundation by hanging the figure of Anubis, which was that of a man with a dog's head, upon all their temples. Histoire de Ciel.

Egypt's shower-less lands. l. 138. There seem to be two situations which may be conceived to be exempted from rain falling upon them, one where the constant trade-winds meet beneath the line, for here two regions of warm air are mixed together, and thence do not seem to have any cause to precipitate their vapour; and the other is, where the winds are brought from colder climates and become warmer by their contact with the earth of a warmer one. Thus Lower Egypt is a flat country warmed by the sun more than the higher lands of one side of it, and than the Mediterranean on the other; and hence the winds which blow over it acquire greater warmth, which ever way they come, than they possessed before, and in consequence have a tendency to acquire and not to part with their vapour like the north-east winds of this country. There is said to be a narrow spot upon the coast of Peru where rain seldom occurs, at the same time according to Ulloa on the mountainous regions of the Andes beyond there is almost perpetual rain. For the wind blows uniformly upon this hot part of the coast of Peru, but no cause of devaporation occurs till it begins to ascend the mountainous Andes, and then its own expansion produces cold sufficient to condense its vapour.

Gigantic SPHINX in circling waves admire,
And MEMNON bending o'er his broken lyre;
O'er furrow'd glebes and green ſavannas ſweep,
And towns and temples laugh amid the deep.

V. I. "High in the frozen North where HECCLA glows,
And melts in torrents his coeval ſnows;
O'er iſles and oceans ſheds a ſanguine light,
Or ſhoots red ſtars amid the ebon night;
When, at his baſe intomb'd, with bellowing ſound
Fell GIESAR roar'd, and ſtruggling ſhook the ground;

Fell Gieſar roar'd. l. 150. The boiling column of water at Gieſar in Iceland was nineteen feet in diameter, and ſometimes roſe to the height of ninety-two feet. On cooling it depoſited a ſiliceous matter or chalcedony forming a baſon round its baſe. The heat of this water before it roſe out of the earth could not be aſcertained, as water looſes all its heat above 212 (as ſoon as it is at liberty to expand) by the exhalation of a part, but the flinty baſon which is depoſited from it ſhews that water with great degrees of heat will diſſolve ſiliceous matter. Van Troil's Letters on Iceland. Since the above account in the year 1780 this part of Iceland has been deſtroyed by an earthquake or covered with lava, which was probably effected by the force of aqueous ſteam, a greater quantity of water falling on the ſubterraneous fires than could eſcape by the antient outlets and generating an increaſed quantity of vapour. For the diſperſion of contagious vapours from volcanos ſee an account of the Harmattan in the notes on Chunda, Vol. II.

Pour'd from red noſtrils, with her ſcalding breath,
A boiling deluge o'er the blaſted heath;
And, wide in air, in miſty volumes hurl'd
Contagious atoms o'er the alarmed world;
NYMPHS! YOUR bold myriads broke the infernal ſpell,
And cruſh'd the Sorcereſs in her flinty cell.

2. "Where with ſoft fires in unextinguiſh'd urns,
Cauldron'd in rock, innocuous Lava burns;
On the bright lake YOUR gelid hands diſtil
In pearly ſhowers the parſimonious rill;
And, as aloft the curling vapours riſe
Through the cleft roof, ambitious for the ſkies,
In vaulted hills condenſe the tepid ſteams,
And pour to HEALTH the medicated ſtreams.
—So in green vales amid her mountains bleak
BUXTONIA ſmiles, the Goddeſs-Nymyh of Peak;

Buxtonia ſmiles. l. 166. Some arguments are mentioned in the note on Fucus Vol. II. to ſhew that the warm ſprings of this country do not ariſe from the decompoſition of pyrites near the ſurface of the earth, but that they are produced by ſteam riſing up the

Deep in warm waves, and pebbly baths ſhe dwells,
And calls HYGEIA to her ſainted wells.

" Hither in ſportive bands bright DEVON leads
Graces and Loves from Chatſworth's flowery meads.-
Charm'd round the NYMPH, they climb the rifted rocks;
And ſteep in mountain-miſt their golden locks;
On venturous ſtep her ſparry caves explore,
And light with radiant eyes her realms of ore;
—Oft by her bubbling founts, and ſhadowy domes,
In gay undreſs the fairy legion roams,
Their dripping palms in playful malice fill,
Or taſte with ruby lip the ſparkling rill;
Croud round her baths, and, bending o'er the ſide,
Unclaſp'd their ſandals, and their zones untied,
Dip with gay fear the ſhuddering foot undreſs'd,
And quick retract it to the fringed veſt;

fiſſures of the mountains from great depths, owing to water falling on ſubterraneous fires, and that this ſteam is condenſed between the ſtrata of the incumbent mountains and collected into ſprings. For further proofs on this ſubject the reader is referred to a Letter from Dr. Darwin in Mr. Pilkington's View of Derbyſhire, Vol. I. p. 256

Or cleave with brandiſh'd arms the lucid ſtream,
And ſob, their blue eyes twinkling in the ſteam.
—High o'er the chequer'd vault with tranſient glow
Bright luſtres dart, as daſh the waves below;
And Echo's ſweet reſponſive voice prolongs
The dulcet tumult of their ſilver tongues.—
O'er their fluſh'd cheeks uncurling treſſes flow,
And dew-drops glitter on their necks of ſnow;
Round each fair Nymph her dropping mantle clings,
And Loves emerging ſhake their ſhowery wings.

And ſob, their blue eyes. l. 184. The bath at Buxton being of 82 degrees of heat is called a warm bath, and is ſo compared with common ſpring-water which poſſeſſes but 48 degrees of heat, but is nevertheleſs a cold bath compared to the heat of the body which is 98. On going into this bath there is therefore always a chill perceived at the firſt immerſion, but after having been in it a minute the chill ceaſes and a ſenſation of warmth ſucceeds though the body continues to be immerſed in the water. The cauſe of this curious phenomenon is to be looked for in the laws of animal ſenſation and not from any property of heat. When a perſon goes from clear day-light into an obſcure room for a while it appears gloomy, which gloom however in a little time ceaſes, and the deficiency of light becomes no longer perceived. This is not ſolely owing to the enlargement of the iris of the eye, ſince that is performed in an inſtant, but to this law of ſenſation, that when a leſs ſtimulus is applied (within certain bounds) the ſenſibility increaſes. Thus at going into a bath as much colder than the body as that of Buxton, the diminution of heat on the ſkin is at firſt perceived, but in about a minute the ſenſibility to heat increaſes and the nerves of the ſkin are equally excited by the leſſened ſtimulus. The ſenſation of warmth at emerging from a cold-bath, and the pain called the hot-ach, after the hands have been immerſed in ſnow, depend on the ſame principle, viz. the increaſed ſenſibility of the ſkin after having been previouſly expoſed to a ſtimulus leſs than uſual.

" Here oft her Lord ſurveys the rude domain,
Fair arts of Greece triumphant in his train;
Lo! as he ſteps, the column'd pile aſcends,
The blue roof cloſes, or the creſcent bends;
New woods aſpiring clothe their hills with green,
Smooth ſlope the lawns, the grey rock peeps between;
Relenting Nature gives her hand to Taſte,
And Health and Beauty crown the laughing waſte.

VI. " Nymphs! your bright ſquadrons watch with chemic eyes
The cold-elaſtic vapours, as they riſe;
With playful force arreſt them as they paſs,
And to *pure* Air betroth the *flaming* Gas.

Here oft her Lord. l. 193. Alluding to the magnificent and beautiful creſcent, and ſuperb ſtables lately erected at Buxton for the accomodation of the company by the Duke of Devonſhire; and to the plantations with which he has decorated the ſurrounding mountains.

And to pure air. l. 204. Until very lately water was eſteemed a ſimple element, nor are all the moſt celebrated chemiſts of Europe yet converts to the new opinion of its decompoſition. Mr. Lavoiſier and others of the French ſchool have moſt ingeniouſly endeavoured to ſhew that water conſiſts of pure air, called by them oxygene, and of

Round their tranſlucent forms at once they fling
Their rapturous arms, with ſilver boſoms cling;
In fleecy clouds their fluttering wings extend,
Or from the ſkies in lucid ſhowers deſcend;
Whence rills and rivers owe their ſecret birth,
And Ocean's hundred arms infold the earth.

"So, robed by Beauty's Queen, with ſofter charms
SATURNIA woo'd the Thunderer to her arms;
O'er her fair limbs a veil of light ſhe ſpread,
And bound a ſtarry diadem on her head;

inflammable air, called hydrogene, with as much of the matter of heat, or calorique, as is neceſſary to preſerve them in the form of gas. Gas is diſtinguiſhed from ſteam by its preſerving its elaſticity under the preſſure of the atmoſphere, and in the greateſt degrees of cold yet known. The hiſtory of the progreſs of this great diſcovery is detailed in the Memoires of the Royal Academy for 1781, and the experimental proofs of it are delivered in Lavoiſier's Elements of Chemiſtry. The reſults of which are that water conſiſts of eighty-five parts by weight of oxygene, and fifteen parts by weight of hydrogene, with a ſufficient quantity of Calorique. Not only numerous chemical phenomena, but many atmoſpherical and vegetable facts receive clear and beautiful elucidation from this important analyſis. In the atmoſphere inflammable air is probably perpetually uniting with vital air and producing moiſture which deſcends in dews and ſhowers, while the growth of vegetables by the aſſiſtance of light is perpetually again decompoſing the water they imbibe from the earth, and while they retain the inflammable air for the formation of oils, wax, honey, reſin, &c. they give up the vital air to repleniſh the atmoſphere.

Long braids of pearl her golden treſſes grac'd,
And the charm'd CESTUS ſparkled round her waiſt.
—Raiſed o'er the woof, by Beauty's hand inwrought,
Breathes the ſoft Sigh, and glows the enamour'd Thought;
Vows on light wings ſucceed, and quiver'd Wiles,
Aſſuaſive Accents, and ſeductive Smiles.
—Slow rolls the Cyprian car in purple pride,
And, ſteer'd by LOVE, aſcends admiring Ide;
Climbs the green ſlopes, the nodding woods pervades,
Burns round the rocks, or gleams amid the ſhades.—
Glad ZEPHYR leads the train, and waves above
The barbed darts, and blazing torch of Love;
Reverts his ſmiling face, and pauſing flings
Soft ſhowers of roſes from aurelian wings.
Delighted Fawns, in wreathes of flowers array'd,
With tiptoe Wood-Boys beat the chequer'd glade;

And ſteer'd by love. l. 222. The younger love, or Cupid, the ſon of Venus, owes his exiſtence and his attributes to much later times than the Eros, or divine love, mentioned in Canto I. ſince the former is no where mentioned by Homer, though ſo many apt opportunities of introducing him occur in the works of that immortal bard. Bacon.

Alarmed Naiads, rifing into air,
Lift o'er their filver urns their leafy hair;
Each to her oak the bafhful Dryads fhrink,
And azure eyes are feen through every chink.
—LOVE culls a flaming fhaft of broadeft wing,
And refts the fork upon the quivering ftring;
Points his arch eye aloft, with fingers ftrong
Draws to his curled ear the filken thong;
Loud twangs the fteel, the golden arrow flies,
Trails a long line of luftre through the fkies;
" 'Tis done!" he fhouts, " the mighty Monarch feels!"
And with loud laughter fhakes the filver wheels;
Bends o'er the car, and whirling, as it moves,
His loofen'd bowftring, drives the rifing doves.
—Pierced on his throne the ftarting Thunderer turns,
Melts with foft fighs, with kindling rapture burns;
Clafps her fair hand, and eyes in fond amaze
The bright Intruder with enamour'd gaze.
" And leaves my Goddefs, like a blooming bride,
" The fanes of Argos for the rocks of Ide?

"Her gorgeous palaces, and amaranth bowers,
"For cliff-top'd mountains, and aerial towers?"
He ſaid; and, leading from her ivory ſeat
The bluſhing Beauty to his lone retreat,
Curtain'd with night the couch imperial ſhrouds,
And reſts the crimſon cuſhions upon clouds.—
Earth feels the grateful influence from above,
Sighs the ſoft Air, and Ocean murmurs love;
Etherial Warmth expands his brooding wing,
And in ſtill ſhowers deſcends the genial Spring.

VII. "NYMPHS OF AQUATIC TASTE! whoſe placid ſmile
Breathes ſweet enchantment o'er BRITANNIA'S iſle;
Whoſe ſportive touch in ſhowers reſplendent flings
Her lucid cataracts, and her bubbling ſprings;
Through peopled vales the liquid ſilver guides,
And ſwells in bright expanſe her freighted tides.

And in ſtill ſhowers. l. 260. The allegorical interpretation of the very antient mythology which ſuppoſes Jupiter to repreſent the ſuperior part of the atmoſphere or ether, and Juno the inferior air, and that the conjunction of theſe two produces vernal ſhowers, as alluded to in Virgil's Georgics, is ſo analogous to the preſent

You with nice ear, in tiptoe trains, pervade
Dim walks of morn or evening's ſilent ſhade;
Join the lone Nightingale, her woods among,
And roll your rills ſymphonious to her ſong;
Through fount-full dells, and wave-worn valleys move,
And tune their echoing waterfalls to love;
Or catch, attentive to the diſtant roar,
The pauſing murmurs of the daſhing ſhore;
Or, as aloud ſhe pours her liquid ſtrain,
Purſue the NEREID on the twilight main.
—Her playful Sea-horſe woos her ſoft commands,
Turns his quick ears, his webbed claws expands,

important diſcovery of the production of water from pure air, or oxygene, and inflammable air, or hydrogene, (which from its greater levity probably reſides over the former,) that one ſhould be tempted to believe that the very antient chemiſts of Egypt had diſcovered the compoſition of water, and thus repreſented it in their hieroglyphic figures before the invention of letters.

In the paſſage of Virgil Jupiter is called ether, and deſcends in prolific ſhowers on the boſom of Juno, whence the ſpring ſucceeds and all nature rejoices.

> Tum pater omnipotens fœcundis imbribus Æther
> Conjugis in gremium lætæ deſcendit, et omnes
> Magnus alit, magno commixtus corpore, fætus.

Virg. Georg. Lib. II. l. 325.

Her playful ſeahorſe. l. 277. Deſcribed form an antique gem.

His watery way with waving volutes wins,
Or liſtening librates on unmoving fins.
The Nymph emerging mounts her ſcaly ſeat,
Hangs o'er his gloſſy ſides her ſilver feet,
With ſnow-white hands her arching veil detains,
Gives to his ſlimy lips the ſlacken'd reins,
Lifts to the ſtar of Eve her eye ſerene,
And chaunts the birth of Beauty's radiant Queen.—
O'er her fair brow her pearly comb unfurls
Her beryl locks, and parts the waving curls,
Each tangled braid with gliſtening teeth unbinds
And with the floating treaſure muſks the winds.—
Thrill'd by the dulcet accents, as ſhe ſings,
The rippling wave in widening circles rings;
Night's ſhadowy forms along the margin gleam
With pointed ears, or dance upon the ſtream;
The Moon tranſported ſtays her bright career,
And maddening Stars ſhoot headlong from the ſphere.

VIII. "NYMPHS! whoſe fair eyes with vivid luſtres glow
For human weal, and melt at human woe;
Late as you floated on your ſilver ſhells,
Sorrowing and ſlow by DERWENT's willowy dells;
Where by tall groves his foamy flood he ſteers
Through ponderous arches o'er impetuous wears,
By DERBY's ſhadowy towers reflective ſweeps,
And gothic grandeur chills his duſky deeps;
You pearl'd with Pity's drops his velvet ſides,
Sigh'd in his gales, and murmur'd in his tides,
Waved o'er his fringed brink a deeper gloom,
And bow'd his alders o'er MILCENA's tomb.

"Oft with ſweet voice She led her infant-train,
Printing with graceful ſtep his ſpangled plain,
Explored his twinkling ſwarms, that ſwim or fly,
And mark'd his florets with botanic eye.—

O'er Milcena's tomb. l. 308. In memory of Mrs. French, a lady who to many other elegant accompliſhments added a proficiency in botany and natural hiſtory.

"Sweet bud of Spring! how frail thy tranſient bloom,
"Fine film," ſhe cried, "of Nature's faireſt loom!
"Soon Beauty fades upon its damaſk throne!"—
—Unconſcious of the worm, that mined her own!—
—Pale are thoſe lips, where ſoft careſſes hung,
Wan the warm cheek, and mute the tender tongue,
Cold reſts that feeling heart on Derwent's ſhore,
And thoſe love-lighted eye-balls roll no more!

IX. "Your virgin trains on Brindley's cradle ſmiled,
And nurſed with fairy-love the unletter'd child,
Spread round his pillow all your ſecret ſpells,
Pierced all your ſprings, and open'd all your wells.—
As now on graſs, with gloſſy folds reveal'd,
Glides the bright ſerpent, now in flowers conceal'd;

On Brindley's cradle ſmiled. l. 321. The life of Mr. Brindley, whoſe great abilities in the conſtruction of canal navigation were called forth by the patronage of the Duke of Bridgwater, may be read in Dr. Kippis's Biographia Britannica, the excellence of his genius is viſible in every part of this iſland. He died at Turnhurſt in Staffordſhire in 1772, and ought to have a monument in the cathedral church at Lichfield.

Far ſhine the ſcales, that gild his ſinuous back,
And lucid undulations mark his track;
So with ſtrong arm immortal BRINDLEY leads
His long canals, and parts the velvet meads;
Winding in lucid lines, the watery maſs
Mines the firm rock, or loads the deep moraſs,
With riſing locks a thouſand hills alarms,
Flings o'er a thouſand ſtreams its ſilver arms,
Feeds the long vale, the nodding woodland laves,
And Plenty, Arts, and Commerce freight the waves.
—NYMPHS! who erewhile round BRINDLEY'S early bier
On ſnow-white boſoms ſhower'd the inceſſant tear,
Adorn his tomb!—oh, raiſe the marble buſt,
Proclaim his honours, and protect his duſt!
With urns inverted, round the ſacred ſhrine
Their ozier wreaths let weeping Naiads twine;
While on the top MECHANIC GENIUS ſtands,
Counts the fleet waves, and balances the lands.

X. " NYMPHS! YOU firſt taught to pierce the ſecret caves
Of humid earth, and lift her ponderous waves;
Bade with quick ſtroke the ſliding piſton bear
The viewleſs columns of incumbent air;—
Preſs'd by the incumbent air the floods below,
Through opening valves in foaming torrents flow,
Foot after foot with leſſen'd impulſe move,
And riſing ſeek the vacancy above.—
So when the Mother, bending o'er his charms,
Claſps her fair nurſeling in delighted arms;

Lift her ponderous waves. l. 346. The invention of the pump is of very antient date, being aſcribed to one Cteſebes an Athenian, whence it was called by the Latins machina Cteſebiana; but it was long before it was known that the aſcent of the piſton lifted the ſuperincumbent column of the atmoſphere, and that then the preſſure of the ſurrounding air on the ſurface of the well below forced the water up into the vacuum, and that on that account in the common lifting pump the water would riſe only about thirty-five feet, as the weight of ſuch a column of water was in general an equipoiſe to the ſurrounding atmoſphere. The foamy appearance of water, when the preſſure of the air over it is diminiſhed, is owing to the expanſion and eſcape of the air previouſly diſſolved by it, or exiſting in its pores. When a child firſt ſucks it only preſſes or champs the teat, as obſerved by the great Harvey, but afterwards it learns to make an incipient vacuum in its mouth, and acts by removing the preſſure of the atmoſphere from the nipple, like a pump.

Throws the thin kerchief from her neck of ſnow,
And half unveils the pearly orbs below;
With ſparkling eye the blameleſs Plunderer owns
Her ſoft embraces, and endearing tones,
Seeks the ſalubrious fount with opening lips,
Spreads his inquiring hands, and ſmiles, and ſips.

" CONNUBIAL FAIR! whom no fond tranſport warms
To lull your infant in maternal arms;
Who, bleſs'd in vain with tumid boſoms, hear
His tender wailings with unfeeling ear;
The ſoothing kiſs and milky rill deny
To the ſweet pouting lip, and gliſtening eye!—
Ah! what avails the cradle's damaſk roof,
The eider bolſter, and embroider'd woof!—
Oft hears the gilded couch unpity'd plains,
And many a tear the taſſel'd cuſhion ſtains!

Ah! what avails. l. 367. From an elegant little poem of Mr. Jerningham's intitled Il Latte, exhorting ladies to nurſe their own children.

No voice ſo ſweet attunes his cares to reſt,
So ſoft no pillow, as his Mother's breaſt!—
—Thus charm'd to ſweet repoſe, when twilight hours
Shed their ſoft influence on celeſtial bowers,
The Cherub, Innocence, with ſmile divine
Shut his white wings, and ſleeps on Beauty's ſhrine.

XI. "From dome to dome when flames infuriate climb,
Sweep the long ſtreet, inveſt the tower ſublime;
Gild the tall vanes amid the aſtoniſh'd night,
And reddening heaven returns the ſanguine light;
While with vaſt ſtrides and briſtling hair aloof
Pale Danger glides along the falling roof;
And Giant Terror howling in amaze
Moves his dark limbs acroſs the lurid blaze.
NYMPHS! YOU firſt taught the gelid wave to riſe,
Hurl'd in reſplendent arches to the ſkies;

Hurl'd in reſplendent arches. l. 386. The addition of an air-cell to machines for raiſing water to extinguiſh fire was firſt introduced by Mr. Newſham of London, and

In iron cells condenſed the airy ſpring,
And imp'd the torrent with unfailing wing;
—On the fierce flames the ſhower impetuous falls,
And ſudden darkneſs ſhrouds the ſhatter'd walls;
Steam, ſmoak, and duſt in blended volumes roll,
And Night and Silence repoſſeſs the Pole.—

" Where were ye, NYMPHS! in thoſe diſaſterous hours,
Which wrap'd in flames AUGUSTA'S ſinking towers?
Why did ye linger in your wells and groves,
When ſad WOODMASON mourn'd her infant loves?

is now applied to ſimilar engines for waſhing wall-trees in gardens, and to all kinds of forcing pumps, and might be applied with advantage to lifting pumps where the water is brought from a great diſtance horizontally. Another kind of machine was invented by one Greyl, in which a veſſel of water was every way diſperſed by the exploſion of gun-powder lodging in the centre of it, and lighted by an adapted match; from this idea Mr. Godfrey propoſed a water-bomb of ſimilar conſtruction. Dr. Hales to prevent the ſpreading of fire propoſed to cover the floors and ſtairs of the adjoining houſes with earth; Mr. Hartley propoſed to prevent houſes from taking fire by covering the cieling with thin iron-plates, and Lord Mahon by a bed of coarſe mortar or plaiſter between the cieling and floor above it. May not this age of chemical ſcience diſcover ſome method of injecting or ſoaking timber with lime-water and afterwards with vitriolic acid, and thus fill its pores with alabaſter? or of penetrating it with ſiliceous matter, by proceſſes ſimilar to thoſe of Bergman and Achard? See Cronſtadt's Mineral. 2d. edit. Vol. I. p. 222.

Woodmaſon, Moleſworth. l. 396. The hiſtories of theſe unfortunate families may be ſeen in the Annual Regiſter, or in the Gentleman's Magazine.

When thy fair Daughters with unheeded ſcreams,
Ill-fated MOLESWORTH! call'd the loitering ſtreams?—
The trembling Nymph on bloodleſs fingers hung
Eyes from the tottering wall the diſtant throng,
With ceaſeleſs ſhrieks her ſleeping friends alarms,
Drops with ſinged hair into her lover's arms.—
The illumin'd Mother ſeeks with footſteps fleet,
Where hangs the ſafe balcony o'er the ſtreet,
Wrap'd in her ſheet her youngeſt hope ſuſpends,
And panting lowers it to her tiptoe friends;
Again ſhe hurries on affection's wings,
And now a third, and now a fourth, ſhe brings;
Safe all her babes, ſhe ſmooths her horrent brow,
And burſts through bickering flames, unſcorch'd, below.
So, by her Son arraign'd, with feet unſhod
O'er burning bars indignant Emma trod.

"E'en on the day when Youth with Beauty wed,
The flames ſurprized them in their nuptial bed;—

Seen at the opening ſaſh with boſom bare,
With wringing hands, and dark diſhevel'd hair,
The bluſhing Beauty with diſorder'd charms
Round her fond lover winds her ivory arms;
Beat, as they claſp, their throbbing hearts with fear,
And many a kiſs is mix'd with many a tear;—
Ah me! in vain the labouring engines pour
Round their pale limbs the ineffectual ſhower!—
—Then craſh'd the floor, while ſinking crouds retire,
And Love and Virtue ſunk amid the fire!—
With piercing ſcreams afflicted ſtrangers mourn,
their white aſhes mingle in their urn.

XII. "Pellucid Forms! whoſe cryſtal boſoms ſhow
The ſhine of welfare, or the ſhade of woe;
Who with ſoft lips ſalute returning Spring,
And hail the Zephyr quivering on his wing;
Or watch, untired, the wintery clouds, and ſhare
With ſtreaming eyes my vegetable care;

Go, ſhove the dim miſt from the mountain's brow,
Chaſe the white fog, which floods the vale below;
Melt the thick ſnows, that linger on the lands,
And catch the hailſtones in your little hands;
Guard the coy bloſſom from the pelting ſhower,
And daſh the rimy ſpangles from the bower;
From each chill leaf the ſilvery drops repel,
And cloſe the timorous floret's golden bell.

Shove the dim miſt. l. 433. See note on l. 20 of this Canto.

Catch the hail-ſtones. l. 436. See note on l. 15 of this Canto.

From each chill leaf. l. 439. The upper ſide of the leaf is the organ of vegetable reſpiration, as explained in the additional notes, No XXXVII, hence the leaf is liable to injury from much moiſture on this ſurface, and is deſtroyed by being ſmeared with oil, in theſe reſpects reſembling the lungs of animals or the ſpiracula of inſects. To prevent theſe injuries ſome leaves repel the dew-drops from their upper ſurfaces as thoſe of cabbages; other vegetables cloſe the upper ſurfaces of their leaves together in the night or in wet weather, as the ſenſitive plant; others only hang their leaves downwards ſo as to ſhoot the wet from them, as kidney-beans, and many trees. See note on l. 18 of this Canto.

Golden bell. l. 440. There are muſcles placed about the footſtalks of the leaves or leaflets of many plants, for the purpoſe of cloſing their upper ſurfaces together, or of bending them down ſo as to ſhoot off the ſhowers or dew-drops, as mentioned in the preceeding note. The claws of the petals or of the diviſions of the calyx of many flowers are furniſhed in a ſimilar manner with muſcles, which are exerted to open or cloſe the corol and calyx of the flower as in tragopogon, anemone. This action of opening and cloſing the leaves or flowers does not appear to be produced ſimply by *irritation* on the muſcles themſelves, but by the connection of thoſe muſcles with a

"So ſhould young Sympathy, in female form,
Climb the tall rock, ſpectatreſs of the ſtorm;
Life's ſinking wrecks with ſecret ſighs deplore,
And bleed for others' woes, Herſelf on ſhore;
To friendleſs Virtue, gaſping on the ſtrand,
Bare her warm heart, her virgin arms expand,
Charm with kind looks, with tender accents cheer,
And pour the ſweet conſolatory tear;
Grief's cureleſs wounds with lenient balms aſſwage,
Or prop with firmer ſtaff the ſteps of Age;

ſenſitive ſenſorium or brain exiſting in each individual bud or flower. 1ſt. Becauſe many flowers cloſe from the defect of ſtimulus, not by the exceſs of it, as by darkneſs, which is the abſence of the ſtimulus of light; or by cold, which is the abſence of the ſtimulus of heat. Now the defect of heat, or, the abſence of food, or of drink, affects our *ſenſations*, which had been previouſly accuſtomed to a greater quantity of them; but a muſcle cannot be ſaid to be ſtimulated into action by a defect of ſtimulus. 2. Becauſe the muſcles around the footſtalks of the ſubdiviſions of the leaves of the ſenſitive plant are exerted when any injury is offered to the other extremity of the leaf, and ſome of the ſtamens of the flowers of the claſs Syngeneſia contract themſelves when others are irritated. See note on Chondrilla, Vol. II. of this work.

From this circumſtance the contraction of the muſcles of vegetables ſeems to depend on a diſagreeable *ſenſation* in ſome diſtant part, and not on the *irritation* of the muſcles themſelves. Thus when a particle of duſt ſtimulates the ball of the eye, the eye-lids are inſtantly cloſed, and when too much light pains the retina, the muſcles of the iris contract its aperture, and this not by any connection or conſent of the nerves of thoſe parts, but as an effort to prevent or to remove a diſagreeable ſenſation, which evinces that vegetables are endued with ſenſation, or that each bud has a common ſenſorium, and is furniſhed with a brain or a central place where its nerves were connected.

The lifted arm of mute Deſpair arreſt,
And ſnatch the dagger pointed to his breaſt;
Or lull to ſlumber Envy's haggard mien,
And* rob her quiver'd ſhafts with hand unſeen.
—Sound, NYMPHS OF HELICON! the trump of Fame,
And teach Hibernian echoes JONES's name;
Bind round her poliſh'd brow the civic bay,
And drag the fair Philanthropiſt to day —
So from ſecluded ſprings, and ſecret caves,
Her Liffy pours his bright meandering waves,
Cools the parch'd vale, the ſultry mead divides,
And towns and temples ſtar his ſhadowy ſides.

XIII. "CALL YOUR light legions, tread the ſwampy heath,
Pierce with ſharp ſpades the tremulous peat beneath·
With colters bright the ruſhy ſward biſect,
And in new veins the guſhing rills direct;—

Jones's name. l. 456. A young lady who devotes a great part of an ample fortune to well choſen acts of ſecret charity.

So flowers ſhall riſe in purple light array'd,
And bloſſom'd orchards ſtretch their ſilver ſhade;
Admiring glebes their amber ears unfold,
And Labour ſleep amid the waving gold.

"Thus when young HERCULES with firm diſdain
Braved the ſoft ſmiles of Pleaſure's harlot train;
To valiant toils his forceful limbs aſſign'd,
And gave to Virtue all his mighty mind,
Fierce ACHELOUS ruſh'd from mountain-caves,
O'er ſad Etolia pour'd his waſteful waves,
O'er lowing vales and bleating paſtures roll'd,
Swept her red vineyards, and her glebes of gold,
Mined all her towns, uptore her rooted woods,
Famine danced upon the ſhining floods.

Fierce Achelous. l. 475. The river Achelous deluged Etolia, by one of its branches or arms, which in the antient languages are called horns, and produced famine throughout a great tract of country, this was repreſented in hieroglyphic emblems by the winding courſe of a ſerpent and the roaring of a bull with large horns. Hercules, or the emblem of ſtrength, ſtrangled the ſerpent, and tore off one horn from the bull; that is, he ſtopped and turned the courſe of one arm of the river, and reſtored plenty to the country. Whence the antient emblem of the horn of plenty. Dict. par M. Danet.

The youthful Hero ſeized his curled creſt,
And daſh'd with lifted club the watery Peſt;
With waving arm the billowy tumult quell'd,
And to his courſe the bellowing Fiend repell'd.

"Then to a Snake the finny Demon turn'd
His lengthen'd form, with ſcales of ſilver burn'd;
Laſh'd with reſiſtleſs ſweep his dragon-train,
And ſhot meandering o'er the affrighted plain.
The Hero-God, with giant fingers claſp'd
Firm round his neck, the hiſſing monſter graſp'd;
With ſtarting eyes, wide throat, and gaping teeth,
Curl his redundant folds, and writhe in death.

"And now a Bull, amid the flying throng
The griſly Demon foam'd, and roar'd along;
With ſilver hoofs the flowery meadows ſpurn'd,
Roll'd his red eye, his threatening antlers turn'd.

Dragg'd down to earth, the Warrior's victor-hands
Preſs'd his deep dewlap on the imprinted ſands;
Then with quick bound his bended knee he fix'd
High on his neck, the branching horns betwixt,
Strain'd his ſtrong arms, his ſinewy ſhoulders bent,
And from his curled brow the twiſted terror rent.
—Pleaſed Fawns and Nymphs with dancing ſtep applaud,
And hang their chaplets round the reſting God;
Link their ſoft hands, and rear with pauſing toil
The golden trophy on the furrow'd ſoil;
Fill with ripe fruits, with wreathed flowers adorn,
And give to PLENTY her prolific horn.

XIV. " On Spring's fair lap, CERULEAN SISTERS! pour
From airy urns the ſun-illumined ſhower,
Feed with the dulcet drops my tender broods,
Mellifluous flowers, and aromatic buds;
Hang from each bending graſs and horrent thorn
The tremulous pearl, that glitters to the morn;

Dragg'd down to earth. l. 497. Deſcribed from an antique gem.

Or where cold dews their ſecret channels lave,
And Earth's dark chambers hide the ſtagnant wave,
O, pierce, YE NYMPHS! her marble veins, and lead
Her guſhing fountains to the thirſty mead;
Wide o'er the ſhining vales, and trickling hills
Spread the bright treaſure in a thouſand rills.
So ſhall my peopled realms of Leaf and Flower
Exult, inebriate with the genial ſhower;

Spread the bright treaſure. l. 520. The practice of flooding lands long in uſe in China has been but lately introduced into this country. Beſides the ſupplying water to the herbage in dryer ſeaſons, it ſeems to defend it from froſt in the early part of the year, and thus doubly advances the vegetation. The waters which riſe from ſprings paſſing through marl or limeſtone are replete with calcareous earth, and when thrown over moraſſes they depoſit this earth and incruſt or conſolidate the moraſs. This kind of earth is depoſited in great quantity from the ſprings at Matlock bath, and ſupplies the ſoft porous limeſtone of which the houſes and walls are there conſtructed; and has formed the whole bank for near a mile on that ſide of the Derwent on which they ſtand.

The water of many ſprings contains much azotic gas, or phlogiſtic air, beſides carbonic gas, or fixed air, as that of Buxton and Bath; this being ſet at liberty may more readily contribute to the production of nitre by means of the putreſcent matters which it is expoſed to by being ſpread upon the ſurface of the land; in the ſame manner as frequently turning over heaps of manure facilitates the nitrous proceſs by impriſoning atmoſpheric air in the interſtices of the putreſcent materials. Water ariſing by land-floods brings along with it much of the moſt ſoluble parts of the manure from the higher lands to the lower ones. River-water in its clear ſtate and thoſe ſprings which are called ſoft are leſs beneficial for the purpoſe of watering lands, as they contain leſs earthy or ſaline matter; and water from diſſolving ſnow from its ſlow ſolution brings but little earth along with it, as may be ſeen by the comparative clearneſs of the water of ſnow-floods.

Dip their long treſſes from the moſſy brink,
With tufted roots the glaſſy currents drink;
Shade your cool manſions from meridian beams,
And view their waving honours in your ſtreams.

" Thus where the veins their confluent branches bend,
And milky eddies with the purple blend;
The Chyle's white trunk, diverging from its ſource,
Seeks through the vital maſs its ſhining courſe;
O'er each red cell, and tiſſued membrane ſpreads
In living net-work all its branching threads;
Maze within maze its tortuous path purſues,
Winds into glands, inextricable clues;
Steals through the ſtomach's velvet ſides, and ſips
The ſilver ſurges with a thouſand lips;
Fills each fine pore, pervades each ſlender hair,
And drinks ſalubrious dew-drops from the air.

" Thus when to kneel in Mecca's awful gloom,
Or preſs with pious kiſs Medina's tomb,

League after league, through many a lingering day,
Steer the ſwart Caravans their ſultry way;
O'er ſandy waſtes on gaſping camels toil,
Or print with pilgrim-ſteps the burning ſoil;
If from lone rocks a ſparkling rill deſcend,
O'er the green brink the kneeling nations bend,
Bathe the parch'd lip, and cool the feveriſh tongue,
And the clear lake reflects the mingled throng."

The Goddess paused,—the liſtening bands awhile
Still ſeem to hear, and dwell upon her ſmile;
Then with ſoft murmur ſweep in lucid trains
Down the green ſlopes, and o'er the pebbly plains,
To each bright ſtream on ſilver ſandals glide,
Reflective fountain, and tumultuous tide.

So ſhoot the Spider-broods at breezy dawn
Their glittering net-work o'er the autumnal lawn;
From blade to blade connect with cordage fine
The unbending graſs, and live along the line;

Or bathe unwet their oily forms, and dwell
With feet repulsive on the dimpling well.

So when the North congeals his watery mass,
Piles high his snows, and floors his seas with glass;
While many a Month, unknown to warmer rays,
Marks its slow chronicle by lunar days;
Stout youths and ruddy damsels, sportive train,
Leave the white soil, and rush upon the main;
From isle to isle the moon-bright squadrons stray,
And win in easy curves their graceful way;
On step alternate borne, with balance nice
Hang o'er the gliding steel, and hiss along the ice.

Argument of the Fourth Canto.

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THE

ECONOMY OF VEGETATION.

CANTO. IV.

AS when at noon in Hybla's fragrant bowers
CACALIA opens all her honey'd flowers;

Cacalia opens. l. 2. The importance of the nectarium or honey-gland in the vegetable economy is seen from the very complicated apparatus, which nature has formed in some flowers for the preservation of their honey from insects, as in the aconites or monkshoods; in other plants instead of a great apparatus for its protection a greater secretion of it is produced that thence a part may be spared to the depredation of insects. The cacalia suaveolens produces so much honey that on some days it may be smelt at a great distance from the plant. I remember once counting on one of these plants besides bees of various kinds without number, above two hundred painted butterflies, which gave it the beautiful appearance of being covered with additional flowers.

Contending ſwarms on bending branches cling,
And nations hover on aurelian wing;
So round the GODDESS, ere ſhe ſpeaks, on high
Impatient SYLPHS in gawdy circlets fly;
Quivering in air their painted plumes expand,
And coloured ſhadows dance upon the land.

I. "SYLPHS! YOUR light troops the tropic Winds confine,
And guide their ſtreaming arrows to the Line;
While in warm floods ecliptic breezes riſe,
And ſink with wings benumb'd in colder ſkies.
YOU bid Monſoons on Indian ſeas reſide,
And veer, as moves the ſun, their airy tide;
While ſouthern gales o'er weſtern oceans roll,
And Eurus ſteals his ice-winds from the Pole.
YOUR playful trains, on ſultry iſlands born,
Turn on fantaſtic toe at eve and morn;
With ſoft ſuſurrant voice alternate ſweep
Earth's green pavilions and encircling deep.

The tropic winds. l. 9. See additional notes, No. XXXIII.

Or in itinerant cohorts, borne ſublime
On tides of ether, float from clime to clime;
O'er waving Autumn bend your airy ring,
Or waft the fragrant boſom of the Spring.

II. "When Morn, eſcorted by the dancing Hours,
O'er the bright plains her dewy luſtre ſhowers;
Till from her ſable chariot Eve ſerene
Drops the dark curtain o'er the brilliant ſcene;
You form with chemic hands the airy ſurge,
Mix with broad vans, with ſhadowy tridents urge.
Sylphs! from each ſun-bright leaf, that twinkling ſhakes
O'er Earth's green lap, or ſhoots amid her lakes,
Your playful bands with ſimpering lips invite,
And wed the enamour'd Oxygene to Light.—

The enamour'd oxygene. l. 34. The common air of the atmoſphere appears by the analyſis of Dr. Prieſtley and other philoſophers to conſiſt of about three parts of an elaſtic fluid unfit for reſpiration or combuſtion, called azote by the French ſchool, and about one fourth of pure vital air fit for the ſupport of animal life and of combuſtion, called oxygene. The principal ſource of the azote is probably from the decompoſition of all vegetable and animal matters by putrefaction and combuſtion; the principal

Round their white necks with fingers interwove,
Cling the ſond Pair with unabating love;
Hand link'd in hand on buoyant ſtep they riſe,
And ſoar and gliſten in unclouded ſkies.
Whence in bright floods the VITAL AIR expands,
And with concentric ſpheres involves the lands;
Pervades the ſwarming ſeas, and heaving earths,
Where teeming Nature broods her myriad births;
Fills the fine lungs of all that *breathe* or *bud*,
Warms the new heart, and dyes the guſhing blood;

ſource of vital air or oxygene is perhaps from the decompoſition of water in the organs of vegetables by means of the ſun's light. The difficulty of injecting vegetable veſſels ſeems to ſhew that their perſpirative pores are much leſs than thoſe of animals, and that the water which conſtitutes their perſpiration is ſo divided at the time of its excluſion that by means of the ſun's light it becomes decompoſed, the inflammable air or hydrogene, which is one of its conſtituent parts, being retained to form the oil, reſin, wax, honey, &c. of the vegetable economy; and the other part, which united with light or heat becomes vital air or oxygene gas, riſes into the atmoſphere and repleniſhes it with the food of life.

Dr. Prieſtley has evinced by very ingenious experiments that the blood gives out phlogiſton, and receives vital air, or oxygene-gas by the lungs. And Dr. Crawford has ſhewn that the blood acquires heat from this vital air in reſpiration. There is however ſtill a ſomething more ſubtil than heat, which muſt be obtained in reſpiration from the vital air, a ſomething which life can not exiſt a few minutes without, which ſeems neceſſary to the vegetable as well as to the animal world, and which as no organized veſſels can confine it, requires perpetually to be renewed. See note on Canto I. l. 407.

With Life's firſt ſpark inſpires the organic frame,
And, as it waſtes, renews the ſubtile flame.

"So pure, ſo ſoft, with ſweet attraction ſhone
Fair Psyche, kneeling at the ethereal throne;
Won with coy ſmiles the admiring court of Jove,
And warm'd the boſom of unconquer'd Love.—
Beneath a moving ſhade of fruits and flowers
Onward they march to Hymen's ſacred bowers;
With lifted torch he lights the feſtive train,
Sublime, and leads them in his golden chain;
Joins the fond pair, indulgent to their vows,
And hides with myſtic veil their bluſhing brows.
Round their fair forms their mingling arms they fling,
Meet with warm lip, and claſp with ruſtling wing.—

Fair Pſyche. l. 48. Deſcribed from an antient gem on a fine onyx in poſſeſſion of the Duke of Marlborough, of which there is a beautiful print in Bryant's Mythol. Vol II. p. 392. And from another antient gem of Cupid and Pſyche embracing, of which there is a print in Spence's Polymetis. p. 82.

—Hence plaſtic Nature, as Oblivion whelms
Her fading forms, repeoples all her realms;
Soft Joys diſport on purple plumes unfurl'd,
And Love and Beauty rule the willing world.

III. 1. "SYLPHS! YOUR bold myriads on the withering heath
Stay the fell SYROC's ſuffocative breath;
Arreſt SIMOOM in his realms of ſand,
The poiſoned javelin balanced in his hand;—

Repeoples all her realms. l. 60.
Quæ mare navigerum et terras frugiferentes
Concelebras, per te quoniam genus omne animantum
Concipitur, viſitque exortum lumina ſolis. Lucret.

Arreſt Simoom. l. 65 "At eleven o'clock while we were with great pleaſure contemplating the rugged tops of Chiggre, where we expected to ſolace ourſelves with plenty of good water, Idris cried out with a loud voice, "fall upon your faces, for here is the ſimoom!" I ſaw from the S. E. a haze come in colour like the purple part of a rainbow, but not ſo compreſſed or thick; it did not occupy twenty yards in breadth, and was about twelve feet high from the ground. It was a kind of a bluſh upon the air, and it moved very rapidly, for I ſcarce could turn to fall upon the ground with my head to the northward, when I felt the heat of its current plainly upon my face. We all lay flat upon the ground, as if dead, till Idris told us it was blown over. The meteor, or purple haze, which I ſaw was indeed paſſed,

Fierce on blue ſtreams he rides the tainted air,
Points his keen eye, and waves his whiſtling hair;
While, as he turns, the undulating ſoil
Rolls in red waves, and billowy deſerts boil. 71

but the light air that ſtill blew was of heat to threaten ſuffocation. For my part I found diſtinctly in my breaſt, that I had imbibed a part of it; nor was I free of an aſthmatic ſenſation till I had been ſome months in Italy." Bruce's Travels. Vol. IV. p. 557.

It is difficult to account for the narrow track of this peſtilential wind, which is ſaid not to exceed twenty yards, and for its ſmall elevation of twelve feet. A whirlwind will paſs forwards, and throw down an avenue of trees by its quick revolution as it paſſes, but nothing like a whirling is deſcribed as happening in theſe narrow ſtreams of air, and whirlwinds aſcend to greater heights. There ſeems but one known manner in which this channel of air could be effected, and that is by electricity.

The volcanic origin of theſe winds is mentioned in the note on Chunda in Vol. II. of this work; it muſt here be added, that Profeſſor Vairo at Naples found, that during the eruption of Veſuvius perpendicular iron bars were electric; and others have obſerved ſuffocating damps to attend theſe eruptions. Ferber's Travels in Italy, p. 133. And laſtly, that a current of air attends the paſſage of electric matter, as is ſeen in preſenting an electrized point to the flame of a candle. In Mr. Bruce's account of this ſimoom, it was in its courſe over a quite dry deſert of ſand, (and which was in conſequence unable to conduct an electric ſtream into the earth beneath it,) to ſome moiſt rocks at but a few miles diſtance; and thence would appear to be a ſtream of electricity from a volcano attended with noxious air; and as the bodies of Mr. Bruce and his attendants were inſulated on the ſand, they would not be ſenſible of their increaſed electricity, as it paſſed over them; to which it may be added, that a ſulphurous or ſuffocating ſenſation is ſaid to accompany flaſhes of lightning, and even ſtrong ſparks of artificial electricity. In the above account of the ſimoom, a great redneſs in the air is ſaid to be a certain ſign of its approach, which may be occaſioned by the eruption of flame from a diſtant volcano in theſe extenſive and impenetrable deſerts of ſand. See Note on l. 292 of this Canto.

You ſeize TORNADO by his locks of miſt,
Burſt his denſe clouds, his wheeling ſpires untwiſt;
Wide o'er the Weſt when borne on headlong gales,
Dark as meridian night, the Monſter ſails,
Howls high in air, and ſhakes his curled brow,
Laſhing with ſerpent-train the waves below,
Whirls his black arm, the forked lightning flings,
And ſhowers a deluge from his demon-wings.

2. "SYLPHS! with light ſhafts YOU pierce the drowſy FOG,
That lingering ſlumbers on the ſedge-wove bog,
With webbed feet o'er midnight meadows creeps,
Or flings his hairy limbs on ſtagnant deeps.

Tornado's. l. 71. See additional notes, No. XXXIII.

On ſtagnant deeps. l. 82. All contagious miaſmata originate either from animal bodies, as thoſe of the ſmall pox, or from putrid moraſſes; theſe latter produce agues in the colder climates, and malignant fevers in the warmer ones. The volcanic vapours which cauſe epidemic coughs, are to be ranked amongſt poiſons, rather than amongſt the miaſmata, which produce contagious diſeaſes.

You meet CONTAGION iſſuing from afar,
And daſh the baleful conqueror from his car;
When, Gueſt of DEATH! from charnel vaults he ſteals,
And bathes in human gore his armed wheels.

"Thus when the PLAGUE, upborne on Belgian air,
Look'd through the miſt and ſhook his clotted hair,
O'er ſhrinking nations ſteer'd malignant clouds,
And rain'd deſtruction on the gaſping crouds.
The beauteous ÆGLE felt the venom'd dart,
Slow roll'd her eye, and feebly throbb'd her heart;
Each fervid ſigh ſeem'd ſhorter than the laſt,
And ſtarting Friendſhip ſhunn'd her, as ſhe paſs'd.
—With weak unſteady ſtep the fainting Maid
Seeks the cold garden's ſolitary ſhade,

The beauteous Ægle. l. 91. When the plague raged in Holland in 1636, a young girl was ſeized with it, had three carbuncles, and was removed to a garden, where her lover, who was betrothed to her, attended her as a nurſe, and ſlept with her as his wife. He remained uninfected, and ſhe recovered, and was married to him. The ſtory is related by Vinc. Fabricius in the Miſc. Cur. Ann. II. Obſ. 188.

Sinks on the pillowy moſs her drooping head,
And prints with lifeleſs limbs her leafy bed.
—On wings of Love her plighted Swain purſues,
Shades her from winds, and ſhelters her from dews,
Extends on tapering poles the canvas roof,
Spreads o'er the ſtraw-wove matt the flaxen woof,
Sweet buds and bloſſoms on her bolſter ſtrows,
And binds his kerchief 'round her aching brows;
Sooths with ſoft kiſs, with tender accents charms,
And claſps the bright Infection in his arms.—
With pale and languid ſmiles the graceful Fair
Applauds his virtues, and rewards his care;
Mourns with wet cheek her fair companions fled
On timorous ſtep, or number'd with the dead;
Calls to her boſom all its ſcatter'd rays,
And pours on THYRSIS the collected blaze;
Braves the chill night, careſſing and careſs'd,
And folds her Hero-lover to her breaſt.—
Leſs bold, LEANDER at the duſky hour
Eyed, as he ſwam, the far love-lighted tower;

Breaſted with ſtruggling arms the toſſing wave,
And ſunk benighted in the watery grave.
Leſs bold, TOBIAS claim'd the nuptial bed,
Where ſeven fond Lovers by a Fiend had bled;
And drove, inſtructed by his Angel-Guide,
The enamour'd Demon from the fatal bride.—
—SYLPHS! while your winnowing pinions fan'd the air,
And ſhed gay viſions o'er the ſleeping pair;
LOVE round their couch effuſed his roſy breath,
And with his keener arrows conquer'd DEATH.

IV. 1. "YOU charm'd, indulgent SYLPHS! their learned toil,
And crown'd with fame your TORRICELL, and BOYLE;

Torricell and Boyle. l. 128. The preſſure of the atmoſphere was diſcovered by Torricelli, a diſciple of Galileo, who had previouſly found that the air had weight. Dr Hook and M. Du Hamel aſcribe the invention of the air-pump to Mr. Boyle, who however confeſſes he had ſome hints concerning its conſtruction from De Guerick. The vacancy at the ſummit of the barometer is termed the Torricellian vacuum, and the exhauſted receiver of an air pump the Boylean vacuum, in honour of theſe two philoſophers.

The miſt and deſcending dew which appear at firſt exhauſting the receiver of an air-pump, are explained in the Phil. Tranſ. Vol. LXXVIII. from the cold produced by

Taught with ſweet ſmiles, reſponſive to their prayer,
The ſpring and preſſure of the viewleſs air.
—How up exhauſted tubes bright currents flow
Of liquid ſilver from the lake below,
Weigh the long column of the incumbent ſkies,
And with the changeful moment fall and riſe.
—How, as in brazen pumps the piſtons move,
The membrane-valve ſuſtains the weight above;

the expanſion of air. For a thermometer placed in the receiver ſinks ſome degrees, and in a very little time, as ſoon as a ſufficient quantity of heat can be acquired from the ſurrounding bodies, the dew becomes again taken up. See additional notes, No. VII. Mr. Sauſſure obſerved on placing his hygrometer in a receiver of an air-pump, that though on beginning to exhauſt it the air became miſty, and parted with its moiſture, yet the hair of his hygrometer contracted, and the inſtrument pointed to greater dryneſs. This unexpected occurrence is explained by M. Monge (Annales de Chymie, Tom. V.) to depend on the want of the uſual preſſure of the atmoſphere to force the aqueous particles into the pores of the hair; and M. Sauſſure ſuppoſes, that his veſicular vapour requires more time to be rediſſolved, than is neceſſary to dry the hair of his thermometer. Eſſais ſur l'Hygrom. p. 226. but I ſuſpect there is a leſs hypothetical way of underſtanding it; when a colder body is brought into warm and moiſt air, (as a bottle of ſpring-water for inſtance,) a ſteam is quickly collected on its ſurface; the contrary occurs when a warmer body is brought into cold and damp air, it continues free from dew ſo long as it continues warm; for it warms the atmoſphere around it, and renders it capable of receiving inſtead of parting with moiſture. The moment the air becomes rarefied in the receiver of the air-pump it becomes colder, as appears by the thermometer, and depoſits its vapour; but the hair of Mr. Sauſſure's hygrometer is now warmer than the air in which it is immerſed, and in conſequence becomes dryer than before, by warming the air which immediately ſurrounds it, a part of its moiſture evaporating along with its heat.

Stroke follows ftroke, the gelid vapour falls,
And mifty dew-drops dim the cryftal walls;
Rare and more rare expands the fluid thin,
And Silence dwells with Vacancy within.—
So in the mighty Void with grim delight
Primeval Silence reign'd with ancient Night.

2. "Sylphs! your foft voices, whifpering from the fkies,
Bade from low earth the bold Mongulfier rife;
Outftretch'd his buoyant ball with airy fpring,
And bore the Sage on levity of wing;—
Where were ye, Sylphs! when on the ethereal main
Young Rosiere launch'd, and call'd your aid in vain?
Fair mounts the light balloon, by Zephyr driven,
Parts the thin clouds, and fails along the heaven;

Young Rofiere launch'd. l. 148. M. Pilatre du Rofiere with a M. Romain rofe in a balloon from Boulogne in June 1785, and after having been about a mile high for about half an hour the balloon took fire, and the two adventurers were dafhed to pieces on their fall to the ground. Mr. Rofiere was a philofopher of great talents and activity, joined with fuch urbanity and elegance of manners, as conciliated the affections of his acquaintance and rendered his misfortune univerfally lamented. Annual Regifter for 1784 and 1785, p. 329.

Higher and yet higher the expanding bubble flies,
Lights with quick flaſh, and burſts amid the ſkies.—
Headlong He ruſhes through the affrighted air
With limbs diſtorted, and diſhevel'd hair,
Whirls round and round, the flying croud alarms,
And DEATH receives him in his ſable arms!—
So erſt with melting wax and looſen'd ſtrings
Sunk hapleſs ICARUS on unfaithful wings;
His ſcatter'd plumage danced upon the wave,
And ſorrowing Mermaids deck'd his watery grave;
O'er his pale corſe their pearly ſea-flowers ſhed,
And ſtrew'd with crimſon moſs his marble bed;
Struck in their coral towers the pauſing bell,
And wide in ocean toll'd his echoing knell.

And wide in ocean. l. 164. Denſer bodies propagate vibration or ſound better than rarer ones; if two ſtones be ſtruck together under the water, they may be heard a mile or two by any one whoſe head is immerſed at that diſtance, according to an experiment of Dr. Franklin. If the ear be applied to one end of a long beam of timber, the ſtroke of a pin at the other end becomes ſenſible; if a poker be ſuſpended in the middle of a garter, each end of which is preſſed againſt the ear, the leaſt percuſſions on the poker give great ſounds. And I am informed by laying the ear on the ground the tread of a horſe may be diſcerned at a great diſtance in the night. The organs of hearing belonging to fiſh are for this reaſon much leſs complicated than of quadrupeds, as the

V. " SYLPHS ! YOU, retiring to sequester'd bowers,
Where oft your PRIESTLEY woos your airy powers, 166

fluid they are immersed in so much better conveys its vibrations. And it is probable that some shell-fish which have twisted shells like the cochlea and semicircular canals of the ears of men and quadrupeds may have no appropriated organ for perceiving the vibrations of the element they live in, but may by their spiral form be in a manner all ear.

Where oft your Priestley. l. 166. The fame of Dr. Priestley is known in every part of the earth where science has penetrated. His various discoveries respecting the analysis of the atmosphere, and the production of variety of new airs or gasses, can only be clearly understood by reading his Experiments on Airs, (3 vols. octavo, Johnson, London.) the following are amongst his many discoveries. 1. The discovery of nitrous and dephlogisticated airs. 2. The exhibition of the acids and alkalies in the form of air. 3. Ascertaining the purity of respirable air by nitrous air. 4. The restoration of vitiated air by vegetation. 5. The influence of light to enable vegetables to yield pure air. 6. The conversion by means of light of animal and vegetable substances, that would otherwise become putrid and offensive, into nourishment of vegetables. 7. The use of respiration by the blood parting with phlogiston, and imbibing dephlogisticated air.

The experiments here alluded to are, 1. Concerning the production of nitrous gas from dissolving iron and many other metals in nitrous acid, which though first discovered by Dr. Hales (Static. Ess. Vol. I. p. 224) was fully investigated, and applied to the important purpose of distinguishing the purity of atmospheric air by Dr. Priestley. When about two measures of common air and one of nitrous gas are mixed together a red effervescence takes place, and the two airs occupy about one fourth less space than was previously occupied by the common air alone.

2. Concerning the green substance which grows at the bottom of reservoirs of water, which Dr. Priestley discovered to yield much pure air when the sun shone on it. His method of collecting this air is by placing over the green substance, which he believes to be a vegetable of the genus conferva, an inverted bell-glass previously filled with water, which subsides as the air arises; it has since been found that all vegetables give up pure air from their leaves, when the sun shines upon them, but not in the night, which may be owing to the sleep of the plant.

3. The third refers to the great quantity of pure air contained in the calces of metals. The calces were long known to weigh much more than the metallic bodies before calcination, insomuch that 100 pounds of lead will produce 112 pounds of

On noiſeleſs ſtep or quivering pinion glide,
As ſits the Sage with Science by his ſide;
To his charm'd eye in gay undreſs appear,
Or pour your ſecrets on his raptured ear.
How nitrous Gas from iron ingots driven
Drinks with red lips the pureſt breath of heaven;
How, while Conferva from its tender hair
Gives in bright bubbles empyrean air;
The cryſtal floods phlogiſtic ores calcine,
And the pure ETHER marries with the MINE.

" So in Sicilia's ever-blooming ſhade
When playful PROSERPINE from CERES ſtray'd,

minium; the ore of manganeſe, which is always found near the ſurface of the earth, is replete with pure air, which is now uſed for the purpoſe of bleaching. Other metals when expoſed to the atmoſphere attract the pure air from it, and become calces by its combination, as zinc, lead, iron; and increaſe in weight in proportion to the air, which they imbibe.

When playful Proſerpine. l. 178. The fable of Proſerpine's being ſeized by Pluto as ſhe was gathering flowers, is explained by Lord Bacon to ſignify the combination or marriage of etherial ſpirit with earthly materials. Bacon's Works, Vol. V. p. 470. edit. 4to. Lond. 1778. This alluſion is ſtill more curiouſly exact, from the late diſcovery of pure air being given up from vegetables, and that then in its unmixed

Led with unwary ſtep her virgin trains
O'er Etna's ſteeps, and Enna's golden plains;
Pluck'd with fair hand the ſilver-bloſſom'd bower,
And purpled mead,—herſelf a fairer flower;
Sudden, unſeen amid the twilight glade,
Ruſh'd gloomy DIS, and ſeized the trembling maid.—
Her ſtarting damſels ſprung from moſſy ſeats,
Dropp'd from their gauzy laps the gather'd ſweets,
Clung round the ſtruggling Nymph, with piercing cries,
Purſued the chariot, and invoked the ſkies;—
Pleaſed as he graſps her in his iron arms,
Frights with ſoft ſighs, with tender words alarms,
The wheels deſcending roll'd in ſmoky rings,
Infernal Cupids flapp'd their demon wings;
Earth with deep yawn received the Fair, amaz'd,
And far in Night celeſtial Beauty blaz'd.

ſtate it more readily combines with metallic or inflammable bodies. From theſe fables which were probably taken from antient hieroglyphics there is frequently reaſon to believe that the Egyptians poſſeſſed much chemical knowledge, which for want of alphabetical writing periſhed with their philoſophers.

VI. "Led by the Sage, Lo! Britain's ſons ſhall guide
Huge SEA-BALLOONS beneath the toſſing tide;
The diving caſtles, roof'd with ſpheric glaſs,
Ribb'd with ſtrong oak, and barr'd with bolts of braſs,
Buoy'd with pure air ſhall endleſs tracks purſue,
And PRIESTLEY'S hand the vital flood renew.—
Then ſhall BRITANNIA rule the wealthy realms,
Which Ocean's wide inſatiate wave o'erwhelms;
Confine in netted bowers his ſcaly flocks,
Part his blue plains, and people all his rocks.

Led by the Sage. l. 195. Dr. Prieſtley's diſcovery of the production of pure air from ſuch variety of ſubſtances will probably ſoon be applied to the improvement of the diving bell, as the ſubſtances which contain vital air in immenſe quantities are of little value as manganeſe and minium. See additional notes, No. XXXIII. In every hundred weight of minium there is combined about twelve pounds of pure air, now as ſixty pounds of water are about a cubic foot, and as air is eight hundred times lighter than water, five hundred weight of minium will produce eight hundred cubic feet of air or about ſix thouſand gallons. Now, as this is at leaſt thrice as pure as atmoſpheric air, a gallon of it may be ſuppoſed to ſerve for three minutes reſpiration for one man. At preſent the air can not be ſet at liberty from minium by viriolic acid without the application of ſome heat, this is however very likely ſoon to be diſcovered, and will then enable adventurers to journey beneath the ocean in large inverted ſhips or diving balloons.

Mr. Boyle relates, that Cornelius Drebelle contrived not only a veſſel to be rowed under water, but alſo a liquor to be caried in that veſſel, which would ſupply the want of freſh air. The veſſel was made by order of James I. and carried twelve rowers beſides paſſengers. It was tried in the river Thames, and one of the perſons who was in that ſubmarine voyage told the particulars of the experiments to a perſon who related them to Mr. Boyle. Annual Regiſter for 1774, p. 248.

Deep, in warm waves beneath the Line that roll,
Beneath the ſhadowy ice-iſles of the Pole,
Onward, through bright meandering vales, afar,
Obedient Sharks ſhall trail her ſceptred car,
With harneſs'd necks the pearly flood diſturb,
Stretch the ſilk rein, and champ the ſilver curb;
Pleaſed round her triumph wondering Tritons play,
And Seamaids hail her on the watery way.
—Oft ſhall ſhe weep beneath the cryſtal waves
O'er ſhipwreck'd lovers weltering in their graves;
Mingling in death the Brave and Good behold
With ſlaves to glory, and with ſlaves to gold;
Shrin'd in the deep ſhall DAY and SPALDING mourn,
Each in his treacherous bell, ſepulchral urn!—

Day and Spalding mourn. l. 217. Mr. Day periſhed in a diving bell, or diving boat, of his own conſtruction at Plymouth in June 1774, in which he was to have continued for a wager twelve hours one hundred feet deep in water, and probably periſhed from his not poſſeſſing all the hydroſtatic knowledge that was neceſſary. See note on Ulva, Vol. II. of this work. See Annual Regiſter for 1774. p. 245.

Mr. Spalding was profeſſionally ingenious in the art of conſtructing and managing the diving bell, and had practiſed the buſineſs many years with ſucceſs. He went down accompanied by one of his young men twice to view the wreck of the Imperial Eaſt-Indiaman at the Kiſh bank in Ireland. On deſcending the third time in June, 1783,

Oft o'er thy lovely daughters, hapleſs PIERCE!
Her ſighs ſhall breathe, her ſorrows dew their hearſe.—
With brow upturn'd to Heaven, "WE WILL NOT PART!"
He cried, and claſp'd them to his aching heart.—
—Daſh'd in dread conflict on the rocky grounds,
Craſh the ſhock'd maſts, the ſtaggering wreck rebounds;
Through gaping ſeams the ruſhing deluge ſwims,
Chills their pale boſoms, bathes their ſhuddering limbs,
Climbs their white ſhoulders, buoys their ſtreaming hair,
And the laſt ſea-ſhriek bellows in the air.—
Each with loud ſobs her tender ſire careſs'd,
And gaſping ſtrain'd him cloſer to her breaſt!—

they remained about an hour under water, and had two barrels of air ſent down to them, but on the ſignals from below not being again repeated, after a certain time, they were drawn up by their aſſiſtants and both found dead in the bell. Annual Regiſter for 1783, p. 206. Theſe two unhappy events may for a time check the ardor of adventurers in traverſing the bottom of the ocean, but it is probable in another half century it may be ſafer to travel under the ocean than over it, ſince Dr. Prieſtley's diſcovery of procuring pure air in ſuch great abundance from the calces of metals.

Hapleſs Pierce! l. 219. The Haſlewell Eaſt-Indiaman, outward bound, was wrecked off Seacomb in the iſle of Purbec on the 6th of January, 1786; when Capt. Pierce, the commander, with two young ladies, his daughters, and the greateſt part of the crew and paſſengers periſhed in the ſea. Some of the officers and about ſeventy ſeamen eſcaped with great difficulty on the rocks, but Capt. Pierce finding it was impoſſible to ſave the lives of the young ladies refuſed to quit the ſhip, and periſhed with them.

—Stretch'd on one bier they ſleep beneath the brine,
And their white bones with ivory arms intwine!

"VII. SYLPHS OF NICE EAR! with beating wings YOU
guide
The fine vibrations of the aerial tide;
Join in ſweet cadences the meaſured words,
Or ſtretch and modulate the trembling cords.
YOU ſtrung to melody the Grecian lyre,
Breathed the rapt ſong, and fan'd the thought of fire,
Or brought in combinations, deep and clear,
Immortal harmony to HANDEL's ear.—
YOU with ſoft breath attune the vernal gale,
When breezy evening broods the liſtening vale;
Or wake the loud tumultuous ſounds, that dwell
In Echo's many-toned, diurnal ſhell.
YOU melt in dulcet chords, when Zephyr rings
The Eolian Harp, and mingle all its ſtrings;

Or trill in air the ſoft ſymphonious chime,
When rapt CECILIA lifts her eye ſublime,
Swell, as ſhe breathes, her boſoms riſing ſnow,
O'er her white teeth in tuneful accents flow,
Through her fair lips on whiſpering pinions move,
And form the tender ſighs, that kindle love!

"So playful LOVE on Ida's flowery ſides
With ribbon-rein the indignant Lion guides;
Pleaſed on his brinded back the lyre he rings,
And ſhakes delirious rapture from the ſtrings;
Slow as the pauſing Monarch ſtalks along,
Sheaths his retractile claws, and drinks the ſong;
Soft Nymphs on timid ſtep the triumph view,
And liſtening Fawns with beating hoofs purſue;

Indignant lion guides. l. 254. Deſcribed from an antient gem, expreſſive of the combined power of love and muſic, in the Muſeum Florent.

With pointed ears the alarmed foreſt ſtarts,
And Love and Muſic ſoften ſavage hearts.

VIII. "Sylphs! your bold hoſts, when Heaven with juſtice dread
Calls the red tempeſt round the guilty head,
Fierce at his nod aſſume vindictive forms,
And launch from airy cars the vollied ſtorms.—
From Aſhur's vales when proud Senacherib trod,
Pour'd his ſwoln heart, defied the living God,
Urged with inceſſant ſhouts his glittering powers;
And Judah ſhook through all her maſſy towers;
Round her ſad altars preſs'd the proſtrate crowd,
Hoſts beat their breaſts, and ſuppliant chieftains bow'd;
Loud ſhrieks of matrons thrill'd the troubled air,
And trembling virgins rent their ſcatter'd hair;
High in the midſt the kneeling King adored,
Spread the blaſpheming ſcroll before the Lord,
Raiſed his pale hands, and breathed his pauſing ſighs,
And fixed on Heaven his dim imploring eyes,—

" Oh! Mighty God!" amidſt thy Seraph-throng
" Who ſit'ſt ſublime, the Judge of Right and Wrong;
" Thine the wide earth, bright ſun, and ſtarry zone,
" That twinkling journey round thy golden throne;
" Thine is the cryſtal ſource of life and light,
" And thine the realms of Death's eternal night.
" Oh, bend thine ear, thy gracious eye incline,
" Lo! Aſhur's King blaſphemes thy holy ſhrine,
" Inſults our offerings, and derides our vows,—
" Oh! ſtrike the diadem from his impious brows,
" Tear from his murderous hand the bloody rod,
" And teach the trembling nations, " Thou art God!"—
—Sylphs! in what dread array with pennons broad
Onward ye floated o'er the ethereal road,
Call'd each dank ſteam the reeking marſh exhales,
Contagious vapours, and volcanic gales,

Volcanic gales. l. 294. The peſtilential winds of the eaſt are deſcribed by various authors under various denominations; as harmattan, ſamiel, ſamium, ſyrocca, kamſin, ſeravanſum. M. de Beauchamp deſcribes a remarkable ſouth wind in the deſerts about Bagdad, called ſeravanſum, or poiſon-wind; it burns the face, impedes reſpiration, ſtrips the trees of their leaves, and is ſaid to paſs on in a ſtreight line, and often kills people in

Gave the soft South with poisonous breath to blow,
And rolled the dreadful whirlwind on the foe!—
Hark! o'er the camp the venom'd tempest sings,
Man falls on Man, on buckler buckler rings;
Groan answers groan, to anguish anguish yields,
And DEATH's loud accents shake the tented fields!
—High rears the Fiend his grinning jaws, and wide
Spans the pale nations with colossal stride,
Waves his broad falchion with uplifted hand,
And his vast shadow darkens all the land.

six hours. P. Cotte sur la Meteorol. Analytical Review for February, 1790. M. Volney says, the hot wind or ramsin seems to blow at the season when the sands of the deserts are the hottest; the air is then filled with an extreamly subtle dust. Vol. I. p. 61. These winds blow in all directions from the deserts; in Egypt the most violent proceed from the S. S. W. at Mecca from the E. at Surat from the N. at Bassora from the N. W. at Bagdad from the W. and in Syria from the S. E.

On the south of Syria, he adds, where the Jordan flows is a country of volcanos; and it is observed that the earthquakes in Syria happen after their rainy season, which is also conformable to a similar observation made by Dr. Shaw in Barbary. Travels in Egypt, Vol. I. p. 303.

These winds seem all to be of volcanic origin, as before mentioned, with this difference, that the Simoom is attended with a stream of electric matter; they seem to be in consequence of earthquakes caused by the monsoon floods, which fall on volcanic fires in Syria, at the same time that they inundate the Nile.

IX. 1. "Ethereal cohorts! Eſſences of Air!
Make the green children of the Spring your care!
Oh, SYLPHS! diſcloſe in this inquiring age
One GOLDEN SECRET to ſome favour'd ſage;
Grant the charm'd taliſman, the chain, that binds,
Or guides the changeful pinions of the winds!
—No more ſhall hoary Boreas, iſſuing forth
With Eurus, lead the tempeſts of the North;
Rime the pale Dawn, or veil'd in flaky ſhowers
Chill the ſweet boſoms of the ſmiling Hours.
By whiſpering Auſter waked ſhall Zephyr riſe,
Meet with ſoft kiſs, and mingle in the ſkies,

One golden ſecret. l. 308. The ſuddenneſs of the change of the wind from N. E. to S. W. ſeems to ſhew that it depends on ſome minute chemical cauſe; which if it was diſcovered might probably, like other chemical cauſes, be governed by human agency; ſuch as blowing up rocks by gunpowder, or extracting the lightening from the clouds. If this could be accompliſhed, it would be the moſt happy diſcovery that ever has happened to theſe northern latitudes, ſince in this country the N. E. winds bring froſt, and the S. W. ones are attended with warmth and moiſture; if the inferior currents of air could be kept perpetually from the S. W. ſupplied by new productions of air at the line, or by ſuperior currents flowing in a contrary direction, the vegetation of this country would be doubled; as in the moiſt vallies of Africa, which know no froſt; the number of its inhabitants would be increaſed, and their lives prolonged; as great abundance of the aged and infirm of mankind, as well as many birds and animals, are deſtroyed by ſevere continued froſts in this climate.

Fan the gay floret, bend the yellow ear,
And rock the uncurtain'd cradle of the year;
Autumn and Spring in lively union blend,
And from the ſkies the Golden Age deſcend.

2. " Caſtled on ice, beneath the circling Bear,
A vaſt CAMELION ſpits and ſwallows air;
O'er twelve degrees his ribs gigantic bend,
And many a league his leathern jaws extend;
Half-fiſh, beneath, his ſcaly volutes ſpread,
And vegetable plumage creſts his head;
Huge fields of air his wrinkled ſkin receives,
From panting gills, wide lungs, and waving leaves;
Then with dread throes ſubſides his bloated form,
His ſhriek the thunder, and his ſigh the ſtorm.
Oft high in heaven the hiſſing Demon wins
His towering courſe, upborne on winnowing fins;

A vaſt Camelion. l. 322. See additional notes, No. XXXIII. on the deſtruction and reproduction of the atmoſphere.

Steers with expanded eye and gaping mouth,
His maſs enormous to the affrighted South;
Spreads o'er the ſhuddering Line his ſhadowy limbs,
And Froſt and Famine follow as he ſwims.—
SYLPHS! round his cloud-built couch your bands array,
And mould the Monſter to your gentle ſway;
Charm with ſoft tones, with tender touches check,
Bend to your golden yoke his willing neck,
With ſilver curb his yielding teeth reſtrain,
And give to KIRWAN's hand the ſilken rein.
—Pleaſed ſhall the Sage, the dragon-wings between,
Bend o'er diſcordant climes his eye ſerene,
With Lapland breezes cool Arabian vales,
And call to Hindoſtan antarctic gales,
Adorn with wreathed ears Kampſchatca's brows,
And ſcatter roſes on Zealandic ſnows,

To Kirwan's hand. l. 342. Mr. Kirwan has publiſhed a valuable treatiſe on the temperature of climates, as a ſtep towards inveſtigating the theory of the winds; and has ſince written ſome ingenious papers on this ſubject in the Tranſactions of the Royal Iriſh Society.

Earth's wondering Zones the genial ſeaſons ſhare,
And nations hail him "MONARCH OF THE AIR."

X. I. "SYLPHS! as you hover on ethereal wing,
Brood the green children of parturient Spring!—
Where in their burſting cells my Embryons reſt,
I charge you guard the vegetable neſt;
Count with nice eye the myriad SEEDS, that ſwell
Each vaulted womb of huſk, or pod, or ſhell;
Feed with ſweet juices, clothe with downy hair,
Or hang, inſhrined, their little orbs in air.

The myriad ſeeds. l. 355. Nature would ſeem to have been wonderfully prodigal in the ſeeds of vegetables, and the ſpawn of fiſh; almoſt any one plant, if all its ſeeds ſhould grow to maturity, would in a few years alone people the terreſtrial globe. Mr. Ray aſſerts that 1012 ſeeds of tobacco weighed only one grain, and that from one tobacco plant the ſeeds thus calculated amounted to 360,000! The ſeeds of the ferns are by him ſuppoſed to exceed a million on a leaf. As the works of nature are governed by general laws this exuberant reproduction prevents the accidental extinction of the ſpecies, at the ſame time that they ſerve for food for the higher orders of animation.

Every ſeed poſſeſſes a reſervoir of nutriment deſigned for the growth of the future plant, this conſiſts of ſtarch, mucilage, or oil, within the coat of the ſeed, or of ſugar and ſubacid pulp in the fruits, which belongs to it.

For the preſervation of the immature ſeed nature has uſed many ingenious methods; ſome are wrapped in down, as the ſeeds of the roſe, bean, and cotton-plant; others are ſuſpended in a large air-veſſel, as thoſe of the bladder-ſena, ſtaphylæa, and pea.

" So, late deſcry'd by HERSCHEL's piercing ſight,
Hang the bright ſquadrons of the twinkling Night;
Ten thouſand marſhall'd ſtars, a ſilver zone,
Effuſe their blended luſtres round her throne;
Suns call to ſuns, in lucid clouds conſpire,
And light exterior ſkies with golden fire;
Reſiſtleſs rolls the illimitable ſphere,
And one great circle forms the unmeaſured year.
—Roll on, YE STARS! exult in youthful prime,
Mark with bright curves the printleſs ſteps of Time;
Near and more near your beamy cars approach,
And leſſening orbs on leſſening orbs encroach;—
Flowers of the ſky! ye too to age muſt yield,
Frail as your ſilken ſiſters of the field!

And light exterior. l. 364. I ſuſpect this line is from Dwight's Conqueſt of Canaan, a poem written by a very young man, and which contains much fine verſification.

Near and more near. l. 269. From the vacant ſpaces in ſome parts of the heavens, and the correſpondent cluſters of ſtars in their vicinity, Mr. Herſchel concludes that the nebulæ or conſtellations of fixed ſtars are approaching each other, and muſt finally coaleſce in one maſs. Phil. Tranſ Vol. LXXV.

Star after ſtar from Heaven's high arch ſhall ruſh,
Suns ſink on ſuns, and ſyſtems ſyſtems cruſh,
Headlong, extinct, to one dark centre fall,
And Death and Night and Chaos mingle all!
—Till o'er the wreck, emerging from the ſtorm,
Immortal NATURE lifts her changeful form,
Mounts from her funeral pyre on wings of flame,
And ſoars and ſhines, another and the ſame.

2. "Lo! on each SEED within its ſlender rind
Life's golden threads in endleſs circles wind;
Maze within maze the lucid webs are roll'd,
And, as they burſt, the living flame unfold.

Till o'er the wreck. l. 377. The ſtory of the phenix riſing from its own aſhes with a twinkling ſtar upon its head, ſeems to have been an antient hieroglyphic emblem of the deſtruction and reſuſcitation of all things.

There is a figure of the great Platonic year with a phenix on his hand on the reverſe of a medal of Adrian. Spence's Polym. p. 189.

Maze within maze. l. 383. The elegant appearance on diſſection of the young tulip in the bulb was firſt obſerved by Mariotte and is mentioned in the note on tulipa in Vol. II. and was afterwards noticed by Du Hamel. Acad. Scien. Lewenhook aſſures us that in the bud of a currant tree he could not only diſcover the ligneous part but even the berries themſelves, appearing like ſmall grapes. Chamb. Dict. art. Bud. Mr. Baker ſays he diſſected a ſeed of trembling graſs in which a perfect plant appeared with its root,

The pulpy acorn, ere it fwells, contains
The Oak's vaft branches in its milky veins;
Each ravel'd bud, fine film, and fibre-line
Traced with nice pencil on the fmall defign.
The young Narciffus, in it's bulb comprefs'd,
Cradles a fecond neftling on its breaft;
In whofe fine arms a younger embryon lies,
Folds its thin leaves, and fhuts its floret-eyes;
Grain within grain fucceffive harvefts dwell,
And boundlefs forefts flumber in a fhell.
—So yon grey precipice, and ivy'd towers,
Long winding meads, and intermingled bowers,

fending forth two branches, from each of which feveral leaves or blades of g[illegible]ceeded. Microfc. Vol. I. p. 252. Mr. Bonnet faw four generations of fuc[illegible] in the bulb of a hyacinth. Bonnet Corps Organ. Vol. I. p. 103. Haller's Phyfiol. Vol. I. p. 91. In the terminal bud of a horfe-chefnut the new flower m[illegible]e feen by the naked eye covered with a mucilaginous down, and the fame in the bulb of a narciffus, as I this morning obferved in feveral of them fent me by Mifs for that purpofe. Sept. 16.

Mr. Ferber fpeaks of the pleafure he received in obferving in the buds of Hepatica and pedicularis hirfuta yet lying hid in the earth, and in the gems of the fhrub daphne mezereon, and at the bafe of ofmunda lunaria a perfect plant of the future year, difcernable in all its parts a year before it comes forth, and in the feeds of nymphea nelumbo the leaves of the plant were feen fo diftinctly that the author found out by them what plant the feeds belonged to. The fame of the feeds of the tulip tree or liriodendum tulipiferum. Amæn. Aced. Vol. VI.

Green files of poplars, o'er the lake that bow,
And glimmering wheel, which rolls and foams below,
In one bright point with nice diftinction lie
Plan'd on the moving tablet of the eye.
—So, fold on fold, Earth's wavy plains extend,
And, fphere in fphere, its hidden ftrata bend;—
Incumbent Spring her beamy plumes expands
O'er reftlefs oceans, and impatient lands,
With genial luftres warms the mighty ball,
And the GREAT SEED evolves, difclofing ALL;
LIFE *buds* or *breathes* from Indus to the Poles,
And the vaft furface kindles, as it rolls!

* *And the great feed.* l. 406. Alluding to the πρωτον ωον, or firft great egg of the antient philofophers, it had a ferpent wrapped round it emblematical of divine wifdom, an image of it was afterwards preferved and worfhipped in the temple of Diofcuri, and fuppofed to reprefent the egg of Leda. See a print of it in Bryant's Mythology. It was faid to have been broken by the horns of the celeftial bull, that is, it was hatched by the warmth of the fpring. See note on Canto I. l. 413.

* *And the vaft furface.* l. 408. L'Organization, le fentiment, le movement fpontané, la vie, n'exiftent qu'a la furface de la terre, et dans le lieux expofes á la lumiere. Traité de Chymie par M. Lavoifier, Tom. I. p. 202.

3. " Come, YE SOFT SYLPHS ! who ſport on Latian land,
Come, ſweet-lip'd Zephyr, and Favonius bland !
Teach the fine SEED, inſtinct with life, to ſhoot
On Earth's cold boſom its deſcending root ;
With Pith elaſtic ſtretch its riſing ſtem,
Part the twin Lobes, expand the throbbing Gem ;
Claſp in your airy arms the aſpiring Plume,
Fan with your balmy breath its kindling bloom,
Each widening ſcale and burſting film unfold,
Swell the green cup, and tint the flower with gold ;

Teach the fine ſeed. l. 411. The ſeeds in their natural ſtate fall on the ſurface of the earth, and having abſorbed ſome moiſture the root ſhoots itſelf downwards into the earth and the plume riſes in air. Thus each endeavouring to ſeek its proper pabulum directed by a vegetable irritability ſimilar to that of the lacteal ſyſtem and to the lungs in animals.

The pith ſeems to puſh up or elongate the bud by its elaſticity, like the pith in the callow quills of birds. This medulla Linneus believes to conſiſt of a bundle of fibres, which diverging breaks through the bark yet gelatinons producing the buds.

The lobes are reſervoirs of prepared nutriment for the young ſeed, which is abſorbed by its placental veſſels, and converted into ſugar, till it has penetrated with its roots far enough into the earth to extract ſufficient moiſture, and has acquired leaves to convert it into nouriſhment. In ſome plants theſe lobes riſe from the earth and ſupply the place of leaves, as in kidney-beans, cucumbers, and hence ſeem to ſerve both as a placenta to the fœtus, and lungs to the young plant. During the proceſs of germination the ſtarch of the ſeed is converted into ſugar, as is ſeen in the proceſe of malting barley for the purpoſe of brewing. And is on this account very ſimilar to the digeſtion of food in the ſtomachs of animals, which converts all their aliment into a chyle which conſiſts of mucilage, oil, and ſugar; the placentation of buds will be ſpoken of hereafter.

While in bright veins the ſilvery Sap aſcends,
And refluent blood in milky eddies bends;
While, ſpread in air, the leaves reſpiring play,
Or drink the golden quinteſſence of day.
—So from his ſhell on Delta's ſhower-leſs iſle
Burſts into life the Monſter of the Nile;
Firſt in tranſlucent lymph with cobweb-threads
The Brain's fine floating tiſſue ſwells, and ſpreads;
Nerve after nerve the gliſtening ſpine deſcends,
The red Heart dances, the Aorta bends;
Through each new gland the purple current glides,
New veins meandering drink the refluent tides;

The ſilvery ſap. l. 419. See additional notes, No. XXXVI.

Or drink the golden. l. 422. Linneus having obſerved the great influence of light on vegetation, imagined that the leaves of plants inhaled electric matter from the light with their upper ſurface. (Syſtem of Vegetables tranſlated, p. 8.)

The effect of light on plants occaſions the actions of the vegetable muſcles of their leaf-ſtalks, which turn the upper ſide of the leaf to the light, and which open their calyxes and chorols, according to the experiments of Abbe Teſſier, who expoſed variety of plants in a cavern to different quantities of light. Hiſt. de L'Academie Royal. Ann. 1783. The ſleep or vigilance of plants ſeems owing to the preſence or abſence of this ſtimulus. See note on Nimoſa, Vol. II.

Edge over edge expands the hardening ſcale,
And ſheaths his ſlimy ſkin in ſilver mail.
—Erewhile, emerging from the brooding ſand,
With Tyger-paw He prints the brineleſs ſtrand,
High on the flood with ſpeckled boſom ſwims,
Helm'd with broad tail, and oar'd with giant limbs;
Rolls his fierce eye-balls, claſps his iron claws,
And champs with gnaſhing teeth his maſſy jaws;
Old Nilus ſighs along his cane-crown'd ſhores,
And ſwarthy Memphis trembles and adores.

XI. "Come, YE SOFT SYLPHS! who fan the Paphian groves,
And bear on ſportive wings the callow Loves;
Call with ſweet whiſper, in each gale that blows,
The ſlumbering Snow-drop from her long repoſe;
Charm the pale Primroſe from her clay-cold bed,
Unveil the baſhful Violet's tremulous head;
While from her bud the playful Tulip breaks,
And young Carnations peep with bluſhing cheeks;

Bid the cloſed *Petals* from nocturnal cold
The virgin *Style* in ſilken curtains fold,
Shake into viewleſs air the morning dews,
And wave in light their irideſcent hues;
While from on high the burſting *Anthers* truſt
To the mild breezes their prolific duſt;
Or bend in rapture o'er the central Fair,
Love out their hour, and leave their lives in air.
So in his ſilken ſepulchre the Worm,
Warm'd with new life, unfolds his larva-form;
Erewhile aloft in wanton circles moves,
And woos on Hymen-wings his velvet loves.

XII. 1. "If prouder branches with exuberance rude
Point their green gems, their barren ſhoots protrude;

Love out their hour. l. 456. The vegetable paſſion of love is agreeably ſeen in the flower of the parnaſſia, in which the males alternately approach and recede from the female, and in the flower of nigella, or devil in the buſh, in which the tall females bend down to their dwarf huſbands. But I was this morning ſurpriſed to obſerve, amongſt Sir Brooke Boothby's valuable collection of plants at Aſhbourn, the manifeſt adultery of ſeveral females of the plant Collinſonia, who had bent themſelves into contact with the males of other flowers of the ſame plant in their vicinity, neglectful of their own. Sept. 16. See additional notes, No. XXXVIII.

Wound them, ye SYLPHS! with little knives, or bind
A wiry ringlet round the ſwelling rind;
Biſect with chiſſel fine the root below,
Or bend to earth the inhoſpitable bough.

Wound them, ye Sylphs! l. 463. Mr. Whitmill adviſed to bind ſome of the moſt vigorous ſhoots with ſtrong wire, and even ſome of the large roots; and Mr. Warner cuts, what he calls a wild worm about the body of the tree, or ſcores the bark quite to the wood like a ſcrew with a ſharp knife. Bradley on Gardening, Vol. II. p. 155. Mr. Fitzgerald produced flowers and fruit on wall trees by cutting off a part of the bark. Phil. Tranſ. Ann. 1761. M. Buffon produced the ſame effect by a ſtraight bandage put round a branch, Act. Paris, Ann. 1738, and concludes that an ingrafted branch bears better from its veſſels being compreſſed by the callous.

A compleat cylinder of the bark about an inch in height was cut off from the branch of a pear tree againſt a wall in Mr. Howard's garden at Lichfield about five years ago, the circumciſed part is now not above half the diameter of the branch above and below it, yet this branch has been full of fruit every year ſince, when the other branches of the tree bore only ſparingly. I lately obſerved that the leaves of this wounded branch were ſmaller and paler, and the fruit leſs in ſize, and ripened ſooner than on the other parts of the tree. Another branch has the bark taken off not quite all round with much the ſame effect.

The theory of this curious vegetable fact has been eſteemed difficult, but receives great light from the foregoing account of the individuallity of buds. A flower-bud dies, when it has perfected its ſeed, like an annual plant, and hence requires no place on the bark for new roots to paſs downwards; but on the contrary leaf-buds, as they advance into ſhoots, form new buds in the axilla of every leaf, which new buds require new roots to paſs down the bark, and thus thicken as well as elongate the branch, now if a wire or ſtring be tied round the bark, many of theſe new roots cannot deſcend, and thence more of the buds will be converted into flower-buds.

And bend to earth. l. 466. Mr. Hitt in his treatiſe on fruit trees obſerves that if a vigorous branch of a wall tree be bent to the horizon, or beneath it, it loſes its vigour and becomes a bearing branch. The theory of this I ſuppoſe to depend on the difficulty with which the leaf-ſhoots can protrude the roots neceſſary for their new progeny of buds upwards along the bended branch to the earth contrary to their natural

So ſhall each germ with new prolific power
Delay the leaf-bud, and expand the flower;
Cloſed in the *Style* the tender pith ſhall end,
The lengthening Wood in circling *Stamens* bend;
The ſmoother Rind its ſoft embroidery ſpread
In vaulted *Petals* o'er their fertile bed;
While the rough Bark, in circling mazes roll'd,
Forms the green *Cup* with many a wrinkled fold;
And each ſmall bud-ſcale ſpreads its foliage hard,
Firm round the callow germ, a *Floral Guard*.

2. "Where cruder juices ſwell the leafy vein,
Stint the young germ, the tender bloſſom ſtain;
On each lop'd ſhoot a foſter ſcion bind,
Pith preſs'd to pith, and rind applied to rind,
So ſhall the trunk with loftier creſt aſcend,
And wide in air its happier arms extend;

habits or powers, whence more flower-ſhoots are produced which do not require new roots to paſs along the bark of the bended branch, but which let their offspring, the ſeeds, fall upon the earth and ſeek roots for themſelves.

Nurſe the new buds, admire the leaves unknown,
And bluſhing bend with fruitage not its own.

"Thus when in holy triumph Aaron trod,
And offer'd on the ſhrine his myſtic rod;
Firſt a new bark its ſilken tiſſue weaves,
New buds emerging widen into leaves;
Fair fruits protrude, enaſcent flowers expand,
And bluſh and tremble round the living wand.

XIII. I. "SYLPHS! on each Oak-bud wound the wormy galls,
With pigmy ſpears, or cruſh the venom'd balls;

Nurſe the new buds. l. 483. Mr. Fairchild budded a paſſion-tree, whoſe leaves were ſpotted with yellow, into one which bears long fruit. The buds did not take, nevertheleſs in a fortnight yellow ſpots began to ſhew themſelves about three feet above the inoculation, and in a ſhort time afterwards yellow ſpots appeared on a ſhoot which came out of the ground from another part of the plant. Bradley, Vol. II. p. 129. Theſe facts are the more curious ſince from experiments of ingrafting red currants on black (Ib. Vol. II.) the fruit does not acquire any change of flavour, and by many other experiments neither colour nor any other change is produced in the fruit ingrafted on other ſtocks.

There is an apple deſcribed in Bradley's work which is ſaid to have one ſide of it a ſweet fruit which boils ſoft, and the other ſide a ſour fruit which boils hard, which Mr.

Fright the green Locuſt from his foamy bed,
Unweave the Caterpillar's gluey thread;
Chaſe the fierce Earwig, ſcare the bloated Toad,
Arreſt the ſnail upon his ſlimy road;
Arm with ſharp thorns the Sweet-brier's tender wood,
And daſh the Cynips from her damaſk bud;
Steep in ambroſial dews the Woodbine's bells,
And drive the Night-moth from her honey'd cells.
So where the Humming-bird in Chili's bowers
On murmuring pinions robs ths pendent flowers;
Seeks, where fine pores their dulcet balm diſtill,
And ſucks the treaſure with proboſcis-bill;
Fair Cyprepedia with ſucceſsfül guile
Knits her ſmooth brow, extinguiſhes her ſmile;

Bradley ſo long ago as the year 1721 ingeniouſly aſcribes to the farina of one of theſe apples impregnating the other, which would ſeem the more probable if we conſider that each diviſion of an apple is a ſeparate womb, and may therefore have a ſeparate impregnation like puppies of different kinds in one litter. The ſame is ſaid to have occurred in oranges and lemons, and grapes of different colours.

Fair Cyprepedia. l. 505. The cyprepedium from South America is ſuppoſed to be of larger ſize and brighter colours than that from North America from which this print is taken; it has a large globular nectary about the ſize of a pidgeon's egg of a

A Spiders bloated paunch and jointed arms
Hide her fine form, and maſk her bluſhing charms;
In ambuſh ſly the mimic warrior lies,
And on quick wing the panting plunderer flies.

2 "Shield the young Harveſt from devouring blight,
The Smut's dark poiſon, and the Mildew white;

fleſhy colour, and an inciſion or depreſſion on its upper part, much reſembling the body of the large American ſpider; this globular nectary is attached to divergent ſlender petals not unlike the legs of the ſame animal. This ſpider is called by Linneus Arenea avicularia, with a convex orbicular thorax, the center tranſverſely excavated, he adds that it catches ſmall birds as well as inſects, and has the venemous bite of a ſerpent. Syſtem Nature, Tom. I. p. 1034. M. Lonvilliers de Poincy, (Hiſtoire Nat. des Antilles, Cap. xiv. art. III.) calls it Phalange, and deſcribes the body to be the ſize of a pidgeon's egg, with a hollow on its back like a navel, and mentions its catching the humming-bird in its ſtrong nets.

The ſimilitude of this flower to this great ſpider ſeems to be a vegetable contrivance to prevent the humming-bird from plundering its honey. About Matlock in Derbyſhire the fly-ophris is produced, the nectary of which ſo much reſembles the ſmall wall bee, perhaps the apis ichneumonea, that it may be eaſily miſtaken for it at a ſmall diſtance. It is probable that by this means it may often eſcape being plundered. See note on lonicera in the next poem.

A bird of our own country called a willow-wren (Motacilla) runs up the ſtem of the crown-imperial (Frittillaria coronalis) and ſips the pendulous drops within its petals. This ſpecies of Motacilla is called by Ray Regulus non criſtatus. White's Hiſt. of Selborne.

Shield the young harveſt. l. 511. Linneus enumerates but four diſeaſes of plants; Eryſyche, the white mucor or mould, with ſeſſile tawny heads, with which the leaves are ſprinkled, as is frequent on the hop, humulus, maple, acer, &c. Rubigo, the ferrugineous powder ſprinkled under the leaves frequent in lady's mantle, alchemilla, &c.



Cypripedium.

London. Published Dec.r 1st 1791 by J. Johnson, St Pauls Church Yard.

Deep-rooted Mould, and Ergot's horn uncouth,
And break the Canker's deſolating tooth.
Firſt in one point the feſtering wound confin'd
Mines unperceived beneath the ſhrivel'd rin'd;
Then climbs the branches with increaſing ſtrength,
Spreads as they ſpread, and lengthens with their length;
—Thus the ſlight wound ingraved on glaſs unneal'd
Runs in white lines along the lucid field;

Clavus, when the ſeeds grow out into larger horns black without, as in rye. This is called Ergot by the french writers.

Uſtulago, when the fruit inſtead of ſeed produces a black powder, as in barley, oats, &c. To which perhaps the honey-dew ought to have been added, and the canker, in the former of which the nouriſhing fluid of the plant ſeems to be exſuded by a retrograde motion of the cutaneous lymphatics, as in the ſweating ſickneſs of the laſt century. The latter is a phagedenic ulcer of the bark, very deſtructive to young apple-trees, and which in cherry-trees is attended with a depoſition of gum arabic, which often terminates in the death of the tree.

Ergot's horn. l. 513. There is a diſeaſe frequently affects the rye in France, and ſometimes in England in moiſt ſeaſons, which is called Ergot, or horn ſeed; the grain becomes conſiderably elongated and is either ſtraight or crooked, containing black meal along with the white, and appears to be pierced by inſects, which were probably the cauſe of the diſeaſe. Mr. Duhamel aſcribes it to this cauſe, and compares it to galls on oak-leaves. By the uſe of this bad grain amongſt the poor diſeaſes have been produced attended with great debility and mortification of the extremities both in France and England. Dict. Raiſon. art. Siegle. Philoſop. Tranſact.

On glaſs unneal'd. l. 519. The glaſs makers occaſionally make what they call *proofs*, which are cooled haſtily, whereas the other glaſs veſſels are removed from warmer ovens to cooler ones, and ſuffered to cool by ſlow degrees, which is called annealing, or nealing

Crack follows crack, to laws elaſtic juſt,
And the frail fabric ſhivers into duſt.

XIV. I. " SYLPHS! if with morn deſtructive Eurus ſprings,
O, claſp the Harebel with your velvet wings;
Screen with thick leaves the Jaſmine as it blows,
And ſhake the white rime from the ſhuddering Roſe;
Whilſt Amaryllis turns with graceful eaſe
Her bluſhing beauties, and eludes the breeze.—
SYLPHS! if at noon the Fritillary droops,
With drops nectarous hang her nodding cups;

them. If an unnealed glaſs be ſcratched by even a grain of ſand falling into it, it will ſeem to conſider of it for ſome time, or even a day, and will then crack into a thouſand pieces,

The ſame happens to a ſmooth ſurfaced lead-ore in Derbyſhire, the workmen having cleared a large face of it ſcratch it with picks, and in a few hours many tons of it crack to pieces and fall, with a kind of exploſion. Whitehurſt's Theory of Earth.

Glaſs dropped into cold water, called Prince Rupert's drops, explode when a ſmall part of their tails are broken off, more ſuddenly indeed, but probably from the ſame cauſe. Are the internal particles of theſe elaſtic bodies kept ſo far from each other by the external cruſt that they are nearly in a ſtate of repulſion into which ſtate they are thrown by their vibrations from any violence applied? Or, like elaſtic balls in certain proportions ſuſpended in contact with each other, can motion once began be increaſed by their elaſticity, till the whole explodes? And can this power be applied to any mechanical purpoſes?



Erythrina Corallodendron.

London. Published Dec.r 1st 1791 by J. Johnson, St Paul's Church Yard.

Thin clouds of Goſſamer in air diſplay,
And hide the vale's chaſte Lily from the ray;
Whilſt Erythrina o'er her tender flower
Bends all her leaves, and braves the ſultry hour;—
Shield, when cold Heſper ſheds his dewy light,
Mimoſa's ſoft ſenſations from the night;
Fold her thin foilage, cloſe her timid flowers,
And with ambroſial ſlumbers guard her bowers;
O'er each warm wall while Cerea flings her arms,
And waſtes on night's dull eye a blaze of charms.

2. Round her tall Elm with dewy fingers twine
The gadding tendrils of the adventurous Vine;

With ambroſial ſlumbers. l. 538. Many vegetables during the night do not ſeem to reſpire, but to ſleep like the dormant animals and inſects in winter. This appears from the mimoſa and many other plants cloſing the upper ſides of their leaves together in their ſleep, and thus precluding that ſide of them from both light and air. And from many flowers cloſing up the poliſhed or interior ſide of their petals, which we have alſo endeavoured to ſhew to be a reſpiratory organ.

The irritability of plants is abundantly evinced by the abſorption and pulmonary circulation of their juices; their ſenſibility is ſhewn by the approaches of the males to the females, and of the females to the males in numerous inſtances; and, as the eſſential circumſtance of ſleep conſiſts in the temporary abolition of voluntary power alone, the ſleep of plants evinces that they poſſeſs voluntary power; which alſo indiſputably appears in many of them by cloſing their petals or their leaves during cold, or rain, or darkneſs, or from mechanic violence.

From arm to arm in gay feſtoons ſuſpend
Her fragrant flowers, her graceful foliage bend;
Swell with ſweet juice her vermil orbs, and feed
Shrined in tranſparent pulp her pearly ſeed;
Hang round the Orange all her ſilver bells,
And guard her fragrance with Heſperian ſpells;
Bud after bud her poliſh'd leaves unfold,
And load her branches with ſucceſſive gold.
So the learn'd Alchemiſt exulting ſees
Riſe in his bright matraſs DIANA's trees;
Drop after drop, with juſt delay he pours
The red-fumed acid on Potoſi's ores;
With ſudden flaſh the fierce bullitions riſe,
And wide in air the gas phlogiſtic flies;
Slow ſhoot, at length, in many a brilliant maſs
Metallic roots acroſs the netted glaſs;
Branch after branch extend their ſilver ſtems,
Bud into gold, and bloſſoms into gems.

So ſits enthron'd in vegetable pride
Imperial KEW by Thames's glittering ſide;
Obedient ſails from realms unfurrow'd bring
For her the unnam'd progeny of ſpring;
Attendant Nymphs her dulcet mandates hear,
And nurſe in foſtering arms the tender year,
Plant the young bulb, inhume the living ſeed,
Prop the weak ſtem, the erring tendril lead;
Or fan in glaſs-built fanes the ſtranger flowers
With milder gales, and ſteep with warmer ſhowers.
Delighted Thames through tropic umbrage glides,
And flowers antarctic, bending o'er his tides;
Drinks the new tints, the ſweets unknown inhales,
And calls the ſons of ſcience to his vales.
In one bright point admiring Nature eyes
The fruits and foliage of diſcordant ſkies,
Twines the gay floret with the fragrant bough,
And bends the wreath round GEORGE's royal brow.
—Sometimes retiring, from the public weal
One tranquil hour the ROYAL PARTNERS ſteal;

Through glades exotic paſs with ſtep ſublime,
Or mark the growths of Britain's happier clime;
With beauty bloſſom'd, and with virtue blaz'd,
Mark the fair Scions, that themſelves have rais'd;
Sweet blooms the Roſe, the towering Oak expands,
The Grace and Guard of Britain's golden lands.

XV. SYLPHS! who, round earth on purple pinions borne,
Attend the radiant chariot of the morn;
Lead the gay hours along the ethereal hight,
And on each dun meridian ſhower the light;
SYLPHS! who from realms of equatorial day
To climes, that ſhudder in the polar ray,
From zone to zone purſue on ſhifting wing,
The bright perennial journey of the ſpring;
Bring my rich Balms from Mecca's hallow'd glades,
Sweet flowers, that glitter in Arabia's ſhades;
Fruits, whoſe fair forms in bright ſucceſſion glow
Gilding the Banks of Arno, or of Po;

Each leaf, whofe fragrant fteam with ruby lip
Gay China's nymphs from pictur'd vafes fip;
Each fpicy rind, which fultry India boafts,
Scenting the night-air round her breezy coafts;
Roots whofe bold ftems in bleak Siberia blow,
And gem with many a tint the eternal fnow;
Barks, whofe broad umbrage high in ether waves
O'er Ande's fteeps, and hides his golden caves;
—And, where yon oak extends his dufky fhoots
Wide o'er the rill, that bubbles from his roots;
Beneath whofe arms, protected from the ftorm
A turf-built altar rears it's ruftic form;
SYLPHS! with religious hands frefh garlands twine,
And deck with lavifh pomp HYGEIA's fhrine.

" Call with loud voice the Sifterhood, that dwell
On floating cloud, wide wave, or bubbling well;
Stamp with charm'd foot, convoke the alarmed Gnomes
From golden beds, and adamantine domes;

Each from her ſphere with beckoning arm invite,
Curl'd with red flame, the Veſtal Forms of light.
Cloſe all your ſpotted wings, in lucid ranks
Preſs with your bending knees the crowded banks,
Croſs your meek arms, incline your wreathed brows,
And win the Goddeſs with unwearied vows.

"Oh, wave, HYGEIA! o'er BRITANNIA's throne
Thy ſerpent-wand, and mark it for thy own;
Lead round her breezy coaſts thy guardian trains,
Her nodding foreſts, and her waving plains;
Shed o'er her peopled realms thy beamy ſmile,
And with thy airy temple crown her iſle!"

The GODDESS ceaſed,—and calling from afar
The wandering Zephyrs, joins them to her car;
Mounts with light bound, and graceful, as ſhe bends,
Whirls the long laſh, the flexile rein extends;
On whiſpering wheels the ſilver axle ſlides,
Climbs into air, and cleaves the cryſtal tides;

Burſt from its pearly chains, her amber hair
Streams o'er her ivory ſhoulders, buoy'd in air;
Swells her white veil, with ruby claſp confined
Round her fair brow, and undulates behind;
The leſſening courſers riſe in ſpiral rings,
Pierce the ſlow-ſailing clouds, and ſtretch their ſhadowy wings.

Verſes omitted by miſtake, to be inſerted after line 320. *Canto* III. *page* 140.

——Here her ſad Conſort, ſtealing through the gloom
Of murmuring cloyſters, gazes on her tomb;
Hangs in mute anguiſh o'er the ſcutcheon'd hearſe,
Or graves with trembling ſtyle the votive verſe.

"Sexton! oh, lay beneath this ſacred ſhrine,
When Time's cold hand ſhall cloſe my aching eyes,
Oh, gently lay this wearied earth of mine,
Where wrap'd in night my loved Milcena lies.

"So ſhall with purer joy my ſpirit move,
When the laſt trumpet thrills the caves of Death,
Catch the firſt whiſpers of my waking love,
And drink with holy kiſs her kindling breath.

"The ſpotleſs Fair, with bluſh ethereal warm,
Shall hail with ſweeter ſmile returning day,
Riſe from her marble bed a brighter form,
And win on buoyant ſtep her airy way.

"Shall bend approved, where beckoning hoſts invite,
On clouds of ſilver her adoring knee,
Approach with Seraphim the throne of light,
—And Beauty plead with angel-tongue for Me!"

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NOTE I.——METEORS.

Etherial Forms! you chaſe the ſhooting ſtars,
Or yoke the vollied lightnings to your cars.

CANTO I. l. 115.

THERE ſeem to be three concentric ſtrata of our incumbent atmoſphere; in which, or between them, are produced four kinds of meteors; lightning, ſhooting ſtars, fire-balls, and northern lights. Firſt, the lower region of air, or that which is denſe enough to reſiſt by the adheſion of its particles the deſcent of condenſed vapour, or clouds, which may extend from one to three or four miles high. In this region the common lightning is produced from the accumulation or defect of electric matter in thoſe floating fields of vapour either in reſpect to each other, or in reſpect to the earth beneath them, or the diſſolved vapour above them, which is conſtantly varying both with the change of the form of the clouds, which thus evolve a greater or leſs ſurface; and alſo with their ever-changing degree of condenſation. As the lightning is thus produced in denſe air, it proceeds but a ſhort courſe on account of the greater reſiſtance which it encounters, is attended with loud exploſions, and appears with a red light.

The ſecond region of the atmoſphere I ſuppoſe to be that which has too little tenacity to ſupport condenſed vapour or clouds; but which yet contains inviſible vapour, or water in aerial ſolution. This aerial ſolution of water differs from that diſſolved in the matter of heat, as it is ſupported by its adheſion to the particles of air, and is not precipitated by cold. In this ſtratum it ſeems probable that the meteors called ſhooting ſtars are produced; and that they conſiſt of electric ſparks, or lightning, paſſing from one region to another of theſe inviſible fields of aero-aqueous ſolution. The height of theſe ſhooting ſtars has not yet been aſcertained by ſufficient obſervation; Dr. Blagden thinks their ſituation is lower down in the atmoſphere than that of fireballs, which he conjectures from their ſwift apparent motion, and aſcribes their ſmallneſs to the more minute diviſion of the electric matter of which they are ſuppoſed to conſiſt, owing to

the geater resistance of the denser medium through which they pass, than that in which the fire-balls exist. Mr. Brydone observed that the shooting stars appeared to him to be as high in the atmosphere, when he was near the summit of mount Etna, as they do when observed from the plain. Phil. Tran. Vol. LXIII.

As the stratum of air, in which shooting stars are supposed to exist is much rarer than that in which lightning resides, and yet much denser than rhat in which fire-balls are produced, they will be attracted at a greater distance than the former, and at a less than the latter. From this rarity of the air so small a sound will be produced by their explosion, as not to reach the lower parts of the atmosphere; their quantity of light from their greater distance being small, is never seen through dense air at all, and thence does not appear red, like lightning or fire balls. There are no apparent clouds to emit or to attract them, because the constituent parts of these aero-aqueous regions may possess an abundance or deficiency of electric matter and yet be in perfect reciprocal solution. And lastly their apparent train of light is probably owing only to a continuance of their impression on the eye; as when a fire-stick is whirled in the dark it gives the appearance of a compleat circle of fire: for these white trains of shooting stars quickly vanish, and do not seem to set any thing on fire in their passage, as seems to happen in the transit of fire-balls.

3. The second region or stratum of air terminates I suppose where the twilight ceases to be refracted, that is, where the air is 3000 times rarer than at the surface of the earth; and where it seems probable that the common air ends, and is surrounded by an atmosphere of inflammable gas tenfold rarer than itself. In this region I believe fire-balls sometimes to pass, and at other times the northern lights to exist. One of these fire-balls or draco volans, was observed by Dr. Pringle and many others on Nov. 26, 1758, which was afterwards estimated to have been a mile and a half in circumference, to have been about one hundred miles high, and to have moved towards the north with a velocity of near thirty miles in a second of time. This meteor had a real tail many miles long, which threw off sparks in its course, and the whole exploded with a sound like distant thunder. Philos. Trans. Vol. LI.

Dr. Blagden has related the history of another large meteor, or fire-ball, which was seen the 18th of August, 1783, with many ingenious observations and conjectures. This was estimated to be between 60 and 70 miles high, and to travel 1000 miles at the rate of about twenty miles in a second. This fire-ball had likewise a real train of light left behind it in its passage, which varied in colour; and in some part of its course gave off sparks or explosions where it had been brightest; and a dusky red streak remained visible perhaps a minute. Philos. Trans. Vol. LXXIV.

These fire-balls differ from lightning, and from shooting stars in many remarkable circumstances; as their very great bulk, being a mile and a half in diameter; their travelling 1000 miles nearly horizontally; their throwing off sparks in their passage; and changing colours from bright blue to dusky red; and leaving a train of fire behind them, continuing about a minute. They differ from the northern lights in not being diffused, but passing from one point of the heavens to another in a defined line; and this in a region above the crepuscular atmosphere, where the air is 3000 times rarer than at the

ſurface of the earth. There has not yet been even a conjecture which can account for theſe appearances!—One I ſhall therefore hazard; which, if it does not inform, may amuſe the reader.

In the note on l. 123, it was ſhewn that there is probably a ſupernatant ſtratum of inflammable gas or hydrogene, over the common atmoſphere; and whoſe denſity at the ſurface where they meet, muſt be at leaſt ten times leſs than that upon which it ſwims; like chemical ether floating upon water, and perhaps without any real contact. 1. In this region, where the aerial atmoſphere terminates and the inflammable one begins, the quantity of tenacity or reſiſtance muſt be almoſt inconceivable; in which a ball of electricity might paſs 1000 miles with greater eaſe than through a thouſandth part of an inch of glaſs. 2. Such a ball of electricity paſſing between inflammable and common air would ſet fire to them in a line as it paſſed along; which would differ in colour according to the greater proportionate commixture of the two airs; and from the ſame cauſe there might occur greater degrees of inflammation, or branches of fire, in ſome parts of its courſe.

As theſe fire-balls travel in a defined line, it is pretty evident from the known laws of electricity, that they muſt be attracted; and as they are a mile or more in diameter, they muſt be emitted from a large ſurface of electric matter; becauſe large nobs give larger ſparks, leſs diffuſed, and more brightly luminous, than leſs ones or points, and reſiſt more forceably the emiſſion of the electric matter. What is there in nature can attract them at ſo great a diſtance as 1000 miles, and ſo forceably as to detach an electric ſpark of a mile diameter? Can volcanos at the time of their eruptions have this effect, as they are generally attended with lightning? Future obſervations muſt diſcover theſe ſecret operations of nature! As a ſtream of common air is carried along with the paſſage of electric aura from one body to another; it is eaſy to conceive, that the common air and the inflammable air between which the fire-ball is ſuppoſed to paſs, will be partially intermixed by being thus agitated, and ſo far as it becomes intermixed it will take fire, and produce the linear flame and branching ſparks above deſcribed. In this circumſtance of their being attracted, and thence paſſing in a defined line, the fire-balls ſeem to differ from the coruſcations of the aurora borealis, or northern lights, which probably take place in the ſame region of the atmoſphere; where the common air exiſts in extreme tenuity, and is covered by a ſtill rarer ſphere of inflammable gas, ten times lighter than itſelf.

As the electric ſtreams, which conſtitute theſe northern lights, ſeem to be repelled or radiated from an accumulation of that fluid in the north, and not attracted like the fire-balls; this accounts for the diffuſion of their light, as well as the ſilence of their paſſage; while their variety of colours, and the permanency of them, and even the breadth of them in different places, may depend on their ſetting on fire the mixture of inflammable and common air through which they paſs; as ſeems to happen in the tranſit of the fire-balls.

It was obſerved by Dr. Prieſtley that the electric ſhock taken through inflammable air was red, in common air it is blueiſh; to theſe circumſtances perhaps ſome of the colours of the northern lights may bear analogy; though the denſity of the medium through which light is ſeen muſt principally vary its colour, as is well explained by Mr. Morgan. Phil. Tranſ. Vol. LXXV. Hence lightning is red when ſeen through a dark cloud, or near the horizon; becauſe the more refrangible rays cannot permeate ſo denſe a medium. But the ſhooting ſtars conſiſt of white light, as they are generally ſeen on clear nights, and nearly vertical: in other ſituations their light is probably too faint to come to us. But as in ſome remarkable appearances of the northern lights, as in March, 1716, all the priſmatic colours were ſeen quickly to ſucceed each other, theſe appear to have been owing to real combuſtion; as the denſity of the interpoſed medium could not be ſuppoſed to change ſo frequently; and therefore theſe colours muſt have been owing to different degrees of heat according to Mr. Morgan's theory of combuſtion. In Smith's Optics, p. 69. the priſmatic colours, and optical deceptions of the northern lights are deſcribed by Mr. Cotes.

The Torricellian vacuum, if perfectly free from air, is ſaid by Mr. Morgan and others to be a perfect non-conductor. This circumſtance therefore would preclude the electric ſtreams from riſing above the atmoſphere. But as Mr. Morgan did not try to paſs an electric ſhock through a vacuum, and as air, or ſomething containing air, ſurrounding the tranſit of electricity may be neceſſary to the production of light, the concluſion may perhaps ſtill be dubious. If however the ſtreams of the northern lights were ſuppoſed to riſe above our atmoſphere, they would only be viſible at each extremity of their courſe; where they emerge from, or are again immerged into the atmoſphere; but not in their journey through the vacuum; for the abſence of electric light in a vacuum is ſufficiently proved by the common experiment of ſhaking a barometer in the dark; the electricity, produced by the friction of the mercury in the glaſs at its top, is luminous if the barometer has a little air in it; but there is no light if the vacuum be complete.

The aurora borealis, or northern dawn, is very ingeniouſly accounted for by Dr. Franklin on principles of electricity. He premiſes the following electric phenomena: 1. that all new fallen ſnow has much poſitive electricity ſtanding on its ſurface. 2. That about twelve degrees of latitude round the poles are covered with a cruſt of eternal ice, which is impervious to the electric fluid. 3. That the denſe part of the atmoſphere riſes but a few miles high; and that in the rarer parts of it the electric fluid will paſs to almoſt any diſtance.

Hence he ſuppoſes there muſt be a great accumulation of poſitive electric matter on the freſh fallen ſnow in the polar regions; which, not being able to paſs through the cruſt of ice into the earth, muſt riſe into the rare air of the upper parts of our atmoſphere, which will the leaſt reſiſt its paſſage; and paſſing towards the equator deſcend again into the denſer atmoſphere, and thence into the earth in ſilent ſtreams. And that many of the appearances attending theſe lights are optical deceptions, owing to the ſituation of the eye that beholds them; which makes all aſcending parallel lines appear to converge to a point.

The idea, above explained in note on l. 123, of the exiſtence of a ſphere of inflammable gas over the aerial atmoſphere would much favour this theory of Dr. Franklin; becauſe in that caſe the denſe aerial atmoſphere would riſe a much leſs height in the polar regions, diminiſhing almoſt to nothing at the pole itſelf; and thus give an eaſier paſſage to the aſcent of the electric fluid. And from the great difference in the ſpecific gravity of the two airs, and the velocity of the earth's rotation, there muſt be a place between the poles and the equator, where the ſuperior atmoſphere of inflammable gas would terminate; which would account for theſe ſtreams of the aurora borealis not appearing near the equator; add to this that it is probable the electric fluid may be heavier than the magnetic one; and will thence by the rotation of the earth's ſurface aſcend over the magnetic one by its centrifugal force; and may thus be induced to riſe through the thin ſtratum of aerial atmoſphere over the poles. See note on Canto II. l. 193. I ſhall have occaſion again to mention this great accumulation of inflammable air over the poles; and to conjecture that theſe northern lights may be produced by the union of inflammable with common air, without the aſſiſtance of the electric ſpark to throw them into combuſtion.

The antiquity of the appearance of northern lights has been doubted; as none were recorded in our annals ſince the remarkable one on Nov. 14, 1574, till another remarkable one on March 6, 1716, and the three following nights, which were ſeen at the ſame time in Ireland, Ruſſia, and Poland, extending near 30 degrees of longitude and from about the 50th degree of latitude over almoſt all the north of Europe. There is however reaſon to believe them of remote antiquity though inaccurately deſcribed; thus the following curious paſſage from the Book of Maccabees, (B. II. c. v.) is ſuch a deſcription of them, as might probably be given by an ignorant and alarmed people. "Through all the city, for the ſpace of almoſt forty days, there were ſeen horſemen running in the air, in cloth of gold, and armed with lances, like a band of ſoldiers; and troops of horſemen in array encountering and running one againſt another, with ſhaking of ſhields and multitude of pikes, and drawing of ſwords, and caſting of darts, and glittering of golden ornaments and harneſs."

NOTE II.——PRIMARY COLOURS.

Cling round the aerial bow with prisms bright,
And pleased untwist the sevenfold threads of light. CANTO I. l. 117.

THE manner in which the rainbow is produced was in some measure understood before Sir Isaac Newton had discovered his theory of colours. The first person who expressly shewed the rainbow to be formed by the reflection of the sunbeams from drops of falling rain was Antonio de Dominis. This was afterwards more fully and distinctly explained by Des Cartes. But what caused the diversity of its colours was not then understood; it was reserved for the immortal Newton to discover that the rays of light consisted of seven combined colours of different refrangibility, which could be seperated at pleasure by a wedge of glass. Pemberton's View of Newton.

Sir Isaac Newton discovered that the prismatic spectrum was composed of seven colours in the following proportions, violet 80, indigo 40, blue 60, green 60, yellow 48, orange 27, red 45. If all these colours be painted on a circular card in the proportions above mentioned, and the card be rapidly whirled on its center, they produce in the eye the sensation of white. And any one of these colours may be imitated by painting a card with the two colours which are contiguous to it, in the same proportions as in the spectrum, and whirling them in the same manner.

My ingenious friend, Mr. Galton of Birmingham, ascertained in this manner by a set of experiments the following propositions; the truth of which he had preconceived from the above data.

1. Any colour in the prismatic spectrum may be imitated by a mixture of the two colours contiguous to it.

2. If any three successive colours in the prismatic spectrum are mixed, they compose only the second or middlemost colour.

3. If any four successive colours in the prismatic spectrum be mixed, a tint similar to a mixture of the second and third colours will be produced, but not precisely the same, because they are not in the same proportion.

4. If beginning with any colour in the circular spectrum, you take of the second colour a quantity equal to the first, second, and third; and add to that the fifth colour, equal in quantity to the fourth, fifth, and sixth; and with these combine the seventh colour in the proportion it exists in the spectrum, white will be produced. Because the first, second, and third, compose only the second; and the fourth, fifth, and sixth, compose only the fifth; therefore if the seventh be added, the same effect is produced, as if all the seven were employed.

5. Beginning with any colour in the circular spectrum, if you take a tint composed of a certain proportion of the second and third, (equal in quantity to the first, second, third, and fourth,) and add to this the sixth colour equal in quantity to the fifth, sixth, and seventh, white will be produced.

From theſe curious experiments of Mr. Galton many phenomena in the chemical changes of colours may probably become better underſtood; eſpecially if, as I ſuppoſe, the ſame theory muſt apply to tranſmitted colours, as to reflected ones. Thus it is well known, that if the glaſs of mangoneſe, which is a tint probably compoſed of violet and indigo, be mixed in a certain proportion with the glaſs of lead, which is yellow; that the mixture becomes tranſparent. Now from Mr. Galton's experiments it appears, that in reflected colours ſuch a mixture would produce white, that is, the ſame as if all the colours were reflected. And therefore in tranſmitted colours the ſame circumſtances muſt produce tranſparency, that is, the ſame as if all the colours were tranſmitted. For the particles, which conſtitute the glaſs of mangoneſe will tranſmit red, violet, indigo, and blue; and thoſe of the glaſs of lead will tranſmit orange, yellow, and green; hence all the primary colours by a mixture of theſe glaſſes become tranſmitted, that is, the glaſs becomes tranſparent.

Mr. Galton has further obſerved that five ſucceſſive priſmatic colours may be combined in ſuch proportions as to produce but one colour, a circumſtance which might be of conſequence in the art of painting. For if you begin at any part of the circular ſpectrum above deſcribed, and take the firſt, ſecond, and third colours in the proportions in which they exiſt in the ſpectrum; theſe will compoſe only the ſecond colour equal in quantity to the firſt, ſecond, and third; add to theſe the third, fourth, and fifth in the proportion they exiſt in the ſpectrum, and theſe will produce the fourth colour equal in quantity to the third, fourth, and fifth. Conſequently this is preciſely the ſame thing, as mixing the ſecond and fourth colours only; which mixture would only produce the third colour. Therefore if you combine the firſt, ſecond, fourth, and fifth in the proportions in which they exiſt in the ſpectrum, with double the quantity of the third colour, this third colour will be produced. It is probable that many of the unexpected changes in mixing colours on a painter's eaſle, as well as in more fluid chemical mixtures, may depend on theſe principles rather than on a new arrangement or combination of their minute particles.

Mr. Galton further obſerves, that white may univerſally be produced by the combination of one priſmatic colour, and a tint intermediate to two others. Which tint may be diſtinguiſhed by a name compounded of the two colours, to which it is intermediate. Thus white is produced by a mixture of red with blue-green. Of orange with indigo-blue. Of Yellow with violet-indigo. Of green with red-violet. Of blue with Orange-red. Of indigo with yellow-orange. Of violet with green-yellow. Which he further remarks exactly coincides with the theory and facts mentioned by Dr. Robert Darwin of Shrewſbury in his account of ocular ſpectra; who has ſhewn that when one of theſe contraſted colours has been long viewed, a ſpectrum or appearance of the other becomes viſible in the fatigued eye. Philoſ. Tranſ. Vol. LXXVI. for the year 1786.

Theſe experiments of Mr. Galton might much aſſiſt the copper-plate printers of callicoes and papers in colours; as three colours or more might be produced by two copper-plates. Thus ſuppoſe ſome yellow figures were put on by the firſt plate, and upon ſome parts of theſe yellow figures and on other parts of the ground blue was laid on by another copper-plate. The three colours of yellow, blue, and green might be produced; as green leaves with yellow and blue flowers.

NOTE III.——COLOURED CLOUDS.

Eve's ſilken couch with gorgeous tints adorn,
Or fire the arrowy throne of riſing morn.

CANTO I. l. 119.

THE rays from the riſing and ſetting ſun are refracted by our ſpherical atmoſphere, hence the moſt refrangible rays, as the violet, indigo, and blue are reflected in greater quantities from the morning and evening ſkies; and the leaſt refrangible ones, as red and orange, are laſt ſeen about the ſetting ſun. Hence Mr. Beguelin obſerved that the ſhadow of his finger on his pocket-book was much bluer in the morning and evening, when the ſhadow was about eight times as long as the body from which it was projected. Mr. Melville obſerves, that the blue rays being more refrangible are bent down in the evenings by our atmoſphere, while the red and orange being leſs refrangible continue to paſs on and tinge the morning and evening clouds with their colours. See Prieſtley's Hiſtory of Light and Colours, p. 440. But as the particles of air, like thoſe of water, are themſelves blue, a blue ſhadow may be ſeen at all times of the day, though much more beautifully in the mornings and evenings, or by means of a candle in the middle of the day. For if a ſhadow on a piece of white paper is produced by placing your finger between the paper and a candle in the day light, the ſhadow will appear very blue; the yellow light of the candle upon the other parts of the paper apparently deepens the blue by its contraſt; theſe colours being oppoſite to each other, as explained in note II.

Colours are produced from clouds or miſts by refraction, as well as by reflection. In riding in the night over an unequal country I obſerved a very beautiful coloured halo round the moon, whenever I was covered with a few feet of miſt, as I aſcended from the vallies; which ceaſed to appear when I roſe above the miſt. This I ſuppoſe was owing to the thinneſs of the ſtratum of miſt, in which I was immerſed; had it been thicker, the colours refracted by the ſmall drops, of which a fog conſiſts, would not have paſſed through it down to my eye.

There is a bright ſpot ſeen on the cornea of the eye, when we face a window, which is much attended to by portrait painters; this is the light reflected from the ſpherical ſurface of the poliſhed cornea, and brought to a focus; if the obſerver is placed in this focus, he ſees the image of the window; if he is placed before or behind the focus, he only ſees a luminous ſpot, which is more luminous and of leſs extent, the nearer he approaches to the focus. The luminous appearance of the eyes of animals in the duſky corners of a room, or in holes in the earth, may ariſe in ſome inſtances from the ſame principle; viz. the reflection of the light from the ſpherical cornea; which will be coloured red or blue in ſome degree by the morning, evening, or meridian light; or by the objects from which that light is previouſly reflected. In the cavern at Colebrook Dale, where the mineral tar exſudes, the eyes of the horſe, which was drawing a cart from within

towards the mouth of it, appeared like two balls of phofphorus, when he was above 100 yards off, and for a long time before any other part of the animal was vifible. In this cafe I fufpect the luminous appearance to have been owing to the light, which had entered the eye, being reflected from the back furface of the vitreous humour, and thence emerging again in parallel rays from the animals eye, as it does from the back furface of the drops of the rainbow, and from the water-drops which lie, perhaps without contact, on cabbage-leaves, and have the brilliancy of quickfilver. This accounts for this luminous appearance being beft feen in thofe animals which have large apertures in their iris, as in cats and horfes, and is the only part vifible in obfcure places, becaufe this is a better reflecting furface than any other part of the animal. If any of thefe emergent rays from the animals eye can be fuppofed to have been reflected from the choroid coat through the femi-tranfparent retina, this would account for the coloured glare of the eyes of dogs or cats and rabits in dark corners.

NOTE IV.——COMETS.

Alarm with comet-blaze the fapphire plain,
The wan ftars glimmering through its filver train.

CANTO I. l. 134.

THERE have been many theories invented to account for the tails of comets. Sir Ifaac Newton thinks that they confift of rare vapours raifed from the nucleus of the comet, and fo rarefied by the fun's heat as to have their general gravitation diminifhed, and that they in confequence afcend oppofite to the fun, and from thence reflect the rays of light. Dr. Halley compares the light of the tails of comets to the ftreams of the aurora berealis, and other electric effluvia. Philof. Tranf. No. 347.

Dr. Hamilton obferves that the light of fmall ftars are feen undiminifhed through both the light of the tails of comets, and of the aurora borealis, and has further illuftrated their electric analogy, and adds that the tails of comets confift of a lucid felf-fhining fubftance which has not the power of refracting or reflecting the rays of light. Effays.

The tail of the comet of 1744 at one time appeared to extend above 16 degrees from its body, and muft have thence been above twenty three millions of miles long. And the comet of 1680, according to the calculations of Dr. Halley on November the 11th, was not above one femi-diameter of the earth, or lefs than 4000 miles to the northward of the way of the earth; at which time had the earth been in that part of its orbit, what might have been the confequence! no one would probably have furvived to have regiftered the tremendous effects.

The comet of 1531, 1607, and 1682 having returned in the year 1759, according to Dr. Halley's prediction in the Philof. Tranf. for 1705, there feems no reafon to doubt that all the other comets will return after their proper periods. Aftronomers have in general acquiefced in the conjecture of Dr. Halley, that the comets of 1532, and 1661 are one and the fame comet, from the fimilarity of the elements of their orbits, and were therefore induced to expect its return to its perihelium 1789. As this comet is liable to be difturbed in its afcent from the fun by the planets Jupiter and Saturn, Dr. Mafkelyne expected its return to its perihelium in the beginning of the year 1789, or the latter end of the year 1788, and certainly fometime before the 27th of April, 1789, which prediction has not been fulfilled. Phil. Tranf. Vol. LXXVI.

NOTE V.——SUN'S RAYS.

Or give the fun's phlogiftic orb to roll. CANTO I. l. 136.

THE difpute among philofophers about phlogifton is not concerning the exiftence of an inflammable principle, but rather whether there be one or more inflammable principles. The difciples of Stahl, which till lately included the whole chemical world believed in the identity of phlogifton in all bodies which would flame or calcine. The difciples of Lavoifier pay homage to a plurality of phlogiftons under the various names of charcoal, fulphur, metals, &c. Whatever will unite with *pure* air, and thence compofe an acid, is efteemed in this ingenious theory to be a different kind of phlogiftic or inflammable body. At the fame time there remains a doubt whether thefe inflammable bodies, as metals, fulphur, charcoal, &c. may not be compounded of the fame phlogifton along with fome other material yet undifcovered, and thus an unity of phlogifton exift, as in the theory of Stahl, though very differently applied in the explication of chemical phenomena.

Some modern philofophers are of opinion that the fun is the great fountain from which the earth and other planets derive all the phlogifton which they poffefs; and that this is formed by the combination of the folar rays with all opake bodies, but particularly with the leaves of vegetables, which they fuppofe to be organs adapted to abforb them. And that as animals receive their nourifhment from vegetables they alfo obtain in a fecondary manner their phlogifton from the fun. And laftly as great maffes of the mineral kingdom, which have been found in the thin cruft of the earth which human labour has penetrated, have evidently been formed from the recrements of animal and vegetable bodies, thefe alfo are fuppofed thus to have derived their phlogifton from the fun.

Another opinion concerning the fun's rays is, that they are not luminous till they arrive at our atmofphere; and that there uniting with fome part of the air they produce

combuſtion, and light is emitted, and that an etherial acid, yet undiſcovered, is formed from this combuſtion.

The more probable opinion is perhaps, that the ſun is a phlogiſtic maſs of matter, whoſe ſurface is in a ſtate of combuſtion, which like other burning bodies emits light with immenſe velocity in all directions; that theſe rays of light act upon all opake bodies, and combining with them either diſplace or produce their elementary heat, and become chemically combined with the phlogiſtic part of them; for light is given out when phlogiſtic bodies unite with the oxygenous principle of the air, as in combuſtion, or in the reduction of metallic calxes; thus in preſenting to the flame of a candle a letter-wafer, (if it be coloured with red-lead,) at the time the red-lead becomes a metallic drop, a flaſh of light is perceived. Dr. Alexander Wilſon very ingeniouſly endeavours to prove that the ſun is only in a ſtate of combuſtion on its ſurface, and that the dark ſpots ſeen on the diſk are excavations or caverns through the luminous cruſt, ſome of which are 4000 miles in diameter. Phil. Tranſ. 1774. Of this I ſhall have occaſion to ſpeak again.

NOTE VI.——CENTRAL FIRES.

Round her ſtill centre tread the burning ſoil,
And watch the billowy Lavas, as they boil. CANTO I. l. 139.

M. DE MAIRAN in a paper publiſhed in the Hiſtoire de l'Academie de Sciences, 1765, has endeavoured to ſhew that the earth receives but a ſmall part of the heat which it poſſeſſes, from the ſun's rays, but is principally heated by fires within itſelf. He thinks the ſun is the cauſe of the viciſſitudes of our ſeaſons of ſummer and winter by a very ſmall quantity of heat in addition to that already reſiding in the earth, which by emanations from the centre to the circumference renders the ſurface habitable, and without which, though the ſun was conſtantly to illuminate two thirds of the globe at once, with a heat equal to that at the equator, it would ſoon become a maſs of ſolid ice. His reaſonings and calculations on this ſubject are too long and too intricate to be inſerted here, but are equally curious and ingenious and carry much conviction along with them.

The opinion that the center of the earth conſiſts of a large maſs of burning lava, has been eſpouſed by Boyle, Boerhave, and many other philoſophers. Some of whom conſidering its ſuppoſed effects on vegetation and the formation of minerals have called it a ſecond ſun. There are many arguments in ſupport of this opinion. 1. Becauſe the power of the ſun does not extend much beyond ten feet deep into the earth, all below being in winter and ſummer always of the ſame degree of heat, viz. 48, which being

much warmer than the mildeſt froſt, is ſuppoſed to be ſuſtained by ſome internal diſtant fire. Add to this however that from experiments made ſome years ago by Dr. Franklin the ſpring-water at Philadelphia appeared to be of 52° of heat, which ſeems further to confirm this opinion, ſince the climates in North America are ſuppoſed to be colder than thoſe of Europe under ſimilar degrees of latitude. 2. Mr. De Luc in going 1359 feet perpendicular into the mines of Hartz on July the 5th, 1778, on a very fine day found the air at the bottom a little warmer than at the top of the ſhaft. Phil. Tranſ. Vol. LXIX. p. 488. In the mines in Hungary, which are 500 cubits deep, the heat becomes very troubleſome when the miners get below 480 feet depth. *Morinus de Locis ſubter.* p. 131. But as ſome other deep mines as mentioned by Mr. Kirwan are ſaid to poſſeſs but the common heat of the earth; and as the cruſt of the globe thus penetrated by human labour is ſo thin compared with the whole, no certain deduction can be made from theſe facts on either ſide of the queſtion. 3. The warm-ſprings in many parts of the earth at great diſtance from any Volcanos ſeem to originate from the condenſation of vapours ariſing from water which is boiled by ſubterraneous fires, and cooled again in their paſſage through a certain length of the colder ſoil; for the theory of chemical ſolution will not explain the equality of their heat at all ſeaſons and through ſo many centuries. See note on Fucus in Vol. II. See a letter on this ſubject in Mr. Pilkinton's View of Derbyſhire from Dr. Darwin. 4. From the ſituations of volcanos which are always found upon the ſummit of the higheſt mountains. For as theſe mountains have been lifted up and loſe ſeveral of their uppermoſt ſtrata as they riſe, the loweſt ſtrata of the earth yet known appear at the tops of the higheſt hills; and the beds of the Volcanos upon theſe hills muſt in conſequence belong to the loweſt ſtrata of the earth, conſiſting perhaps of granite or baſaltes, which were produced before the exiſtance of animal or vegetable bodies, and might conſtitute the original nucleus of the earth, which I have ſuppoſed to have been projected from the ſun, hence the volcanos themſelves appear to be ſpiracula or chimneys belonging to great central fires. It is probably owing to the eſcape of the elaſtic vapours from theſe ſpiracula that the modern earthquakes are of ſuch ſmall extent compared with thoſe of remote antiquity, of which the veſtiges remain all over the globe. 5. The great ſize and height of the continents, and the great ſize and depth of the South-ſea, Atlantic, and other oceans, evince that the firſt earthquakes, which produced theſe immenſe changes in the globe, muſt have been occaſioned by central fires. 6. The very diſtant and expeditious communication of the ſhocks of ſome great earthquakes. The earthquake at Liſbon in 1755 was perceived in Scotland, in the Peak of Derbyſhire, and in many other diſtant parts of Europe. The percuſſions of it travelled with about the velocity of ſound, viz. about thirteen miles in a minute. The earthquake in 1693 extended 2600 leagues. (Goldſmith's Hiſtory.) Theſe phenomena are eaſily explained if the central parts of the earth conſiſt of a fluid lava, as a percuſſion on one part of ſuch a fluid maſs would be felt on other parts of its confining vault, like a ſtroke on a fluid contained in a bladder, which however gentle on one ſide is perceptible to the hand placed on the other; and the velocity with which ſuch a concuſſion would travel would be that of ſound, or thirteen miles in a minute. For further information on this part of the ſubject the reader is referred to Mr. Michell's excellent Treatiſe on Earthquakes in the

Philof. Tranf. Vol. LI. 7. That there is a cavity at the center of the earth is made probable by the late experiments on the attraction of mountains by Mr. Mafkerlyne, who fuppofed from other confiderations that the denfity of the earth near the furface fhould be five times lefs than its mean denfity. Phil. Tranf. Vol. LXV. p. 498. But found from the attraction of the mountain Schehallien, that it is probable, the mean denfity of the earth is but double that of the hill. Ibid. p. 532. Hence if the firft fuppofition be well founded there would appear to be a cavity at the centre of confiderable magnitude, from whence the immenfe beds and mountains of lava, toadftone, bafaltes, granite, &c. have been protruded. 8. The variation of the compafs can only be accounted for by fuppofing the central parts of the earth to confift of a fluid mafs, and that part of this fluid is iron, which requiring a greater degree of heat to bring it into fufion than glafs or other metals, remains a folid, and the vis inertiæ of this fluid mafs with the iron in it, occafions it to perform fewer revolutions than the cruft of folid earth over it, and thus it is gradually left behind, and the place where the floating iron refides is pointed to by the direct or retrograde motions of the magnetic needle. This feems to have been nearly the opinion of Dr. Halley and Mr. Euler.

NOTE VII.—ELEMENTARY HEAT.

Or fphere on fphere in widening waves expand,
And glad with genial warmth the incumbent land. CANTO I. l. 143.

A CERTAIN quantity of heat feems to be combined with all bodies befides the fenfible quantity which gravitates like the electric fluid amongft them. This combined heat or latent heat of Dr. Black, when fet at liberty by fermentation, inflammation, cryftallization, freezing, or other chemical attractions producing new *combinations*, paffes as a fluid element into the furrounding bodies. And by thawing, diffufion of neutral falts in water, melting, and other chemical *folutions*, a portion of heat is attracted from the bodies in vicinity and enters into or becomes combined with the new folutions.

Hence a *combination* of metals with acids, of effential oils and acids, of alcohol and water, of acids and water, give out heat; whilft a *folution* of fnow in water or in acids, and of neutral falts in water, attract heat from the furrounding bodies. So the acid of nitre mixed with oil of cloves unites with it and produces a moft violent flame; the fame acid of nitre poured on fnow inftantly diffolves it and produces the greateft degree of cold yet known, by which at Peterfburgh quickfilver was firft frozen in 1760.

Water may be cooled below 32° without being frozen, if it be placed on a folid floor and fecured from agitation, but when thus cooled below the freezing point the leaft

agitation turns part of it suddenly into ice, and when this sudden freezing takes place a thermometer placed in it instantly rises as some heat is given out in the act of congelation, and the ice is thus left with the same *sensible* degree of cold as the water had possessed before it was agitated, but is nevertheless now combined with less *latent* heat.

A cubic inch of water thus cooled down to 32° mixed with an equal quantity of boiling water at 212° will cool it to the middle number between these two, or to 122. But a cubit inch of ice whose sensible cold also is but 32, mixed with an equal quantity of boiling water, will cool it six times as much as the cubic inch of cold water above-mentioned, as the ice not only gains its share of the sensible or gravitating heat of the boiling water but attracts to itself also and combines with the quantity of latent heat which it had lost at the time of its congelation.

So boiling water will acquire but 212° of heat under the common pressure of the atmosphere, but the steam raised from it by its expansion or by its solution in the atmosphere combines with and carries away a prodigious quantity of heat which it again parts with on its condensation; as is seen in common distillation where the large quantity of water in the worm-tub is so soon heated. Hence the evaporation of ether from a thermometer soon sinks the mercury below freezing, and hence a warmth of the air in winter frequently succeeds a shower.

When the matter of heat or calorique is set at liberty from its combinations, as by inflammation, it passes into the surrounding bodies, which possess different capacities of acquiring their share of the loose or sensible heat; thus a pint measure of cold water at 48° mixed with a pint of boiling water at 212° will cool it to the degree between these two numbers, or to 154°, but it requires two pint measures of quicksilver at 48° of heat to cool one pint of water as above. These and other curious experiments are adduced by Dr. Black to evince the existance of combined or latent heat in bodies, as has been explained by some of his pupils, and well illustrated by Dr. Crawford. The world has long been in expectation of an account of his discoveries on this subject by the celebrated author himself.

As this doctrine of elementary heat in its fluid and combined state is not yet universally received, I shall here add two arguments in support of it drawn from different sources, viz. from the heat given out or absorbed by the mechanical condensation or expansion of the air, and perhaps of other bodies, and from the analogy of the various phenomena of heat with those of electricity.

I. If a thermometer be placed in the receiver of an air-pump, and the air hastily exhausted, the thermometer will sink some degrees, and the glass become steamy; the same occurs in hastily admitting a part of the air again. This I suppose to be produced by the expansion of part of the air, both during the exhaustion and re-admission of it and that the air so expanded becomes capable of attracting from the bodies in its vicinity a part of their heat, hence the vapours contained in it and the glass receiver are for a time colder and the steam is precipitated. That the air thus parts with its moisture from the cold occasioned by its rarefaction and not simply by the rarefaction itself is evident, because in a minute or two the same rarefied air will again take up the dew deposited on the receiver; and because water will evaporate sooner in rare than in dense air.

There is a curious phenomenon ſimilar to this obſerved in the fountain of Hiero conſtructed on a large ſcale at the Chemnicenſian mines in Hungary. In this machine the air in a large veſſel is compreſſed by a column of water 260 feet high, a ſtop-cock is then opened, and as the air iſſues out with great vehemence, and thus becomes immediately greatly expanded, ſo much cold is produced that the moiſture from this ſtream of air is precipitated in the form of ſnow, and ice is formed adhering to the noſel of the cock. This remarkable circumſtance is deſcribed at large with a plate of the machine in Philoſ. Tranſ. Vol. LII. for 1761.

The following experiment is related by Dr. Darwin in the Philoſ. Tranſ. Vol. [illegible]VIII. Having charged an air-gun as forcibly as he well could the air-cell and ſyringe [illegible] exceedingly hot, much more ſo than could be aſcribed to the friction in working [illegible] then left about half an hour to cool down to the temperature of the air, and a [illegible] having been previouſly fixed againſt a wall, the air was diſcharged in a con[illegible] on its bulb, and it ſunk many degrees. From theſe three experiments [illegible] the exhauſted receiver being depoſited and re-abſorbed, when a part of the [illegible] ated, and the ſnow produced by the fountain of Hiero, and [illegible] out in charging, and the cold produced in diſcharging an [illegible] conclude that when air is mechanically compreſſed the [illegible] out of it, and that when it is mechanically expanded the [illegible] from the common maſs.

It is probable all other bodies as well as air attract heat from their neighbours when they are mechanically expanded, and give it out when they are mechanically condenſed. Thus when a vibration of the particles of hard bodies is excited by friction or by percuſſion, theſe particles mutually recede from and approach each other reciprocally; at the times of their receſſion from each other, the body becomes enlarged in bulk, and is then in a condition to attract heat from thoſe in its vicinity with great and ſudden power; [illegible] times of their approach to each other this heat is again given out, but the bodies [illegible] having in the mean while received the heat they had thus loſt, from other bodies [illegible] them, do not ſo ſuddenly or ſo forcibly re-abſorb the heat again from the body in [illegible] hence it remains on its ſurface like the electric fluid on a rubbed glaſs globe, and [illegible] reaſon, becauſe there is no good conductor to take it up again. Hence at every [illegible] more and more heat is acquired and ſtands looſe upon the ſurface; as in filing metals or rubbing glaſs tubes; and thus a ſmith with a few ſtrokes on a nail on his anvil can make it hot enough to light a brimſtone-match; and hence in ſtriking flint and ſteel together heat enough is produced to vitrify the parts thus ſtrucken off, the quantity of which heat is again probably increaſed by the new chemical combination.

II. [illegible] analogy between the phenomena of the electric fluid and of heat furniſhes [illegible] in ſupport of the exiſtence of heat as a gravitating fluid. 1. They are both [illegible] by friction on the excited body. 2. They are propagated eaſily or with difficulty along the ſame claſſes of bodies; with eaſe by metals, with leſs eaſe by water: and with difficulty by reſins, bees-wax, ſilk, air, and glaſs. Thus glaſs canes or canes of ſealing-wax may be melted by a blow-pipe or a candle within a quarter of an

inch of the fingers which hold them, without any inconvenient heat, while a pin or other metallic fubftance applyed to the flame of a candle fo readily conducts the heat as immediately to burn the fingers. Hence clothes of filk keep the body warmer than clothes of linen of equal thicknefs, by confining the heat upon the body. And hence plains are fo much warmer than the fummits of mountains by the greater denfity of the air confining the acquired heat upon them. 3. They both give out light in their paffage through air, perhaps not in their paffage through a vacuum. 4. They both of them fufe or vitrify metals. 5. Bodies after being electrized if they are mechanically extended will receive a greater quantity of electricity, as in Dr. Franklin's experiment of the chain in the tankard; the fame feems true in refpect to heat as explained above. 6. Both heat and electricity contribute to fufpend fteam in the atmofphere by producing or increafing the repulfion of its particles. 7. They both gravitate, when they have been accumulated, till they find their equilibrium.

If we add to the above the many chemical experiments which receive an eafy and elegant explanation from the fuppofed matter of heat, as employed in the works of Bergman and Lavoifier, I think we may reafonably allow of its exiftence as an element, occafionally combined with other bodies, and occafionally exifting as a fluid, like the electric fluid gravitating amongft them. and that hence it may be propagated from the central fires of the earth to the whole mafs, and contribute to preferve the mean heat of the earth, which in this country is about 48 degrees but variable from the greater or lefs effect of the fun's heat in different climates, fo well explained in Mr. Kirwan's Treatife on the Temperature of different Latitudes. 1787, Elmfly. London.

NOTE VIII.——MEMNON'S LYRE.

So to the ſacred Sun in Memnon's fane
Spontaneous concords quired the matin ſtrain. . CANTO I. l. 181.

THE gigantic ſtatue of Memnon in his temple at Thebes had a lyre in his hands, which many credible writers aſſure us, ſounded when the riſing ſun ſhone upon it. Some philoſophers have ſuppoſed that the ſun's light poſſeſſes a mechanical impulſe, and that the ſounds abovementioned might be thence produced. Mr. Michell conſtructed a very tender horizontal balance, as related by Dr. Prieſtley in his hiſtory of light and colours, for this purpoſe, but ſome experiments with this balance which I ſaw made by the late Dr. Powel, who threw the focus of a large reflector on one extremity of it, were not concluſive eitherway, as the copper leaf of the balance approached in one experiment and receded in another.

There are however methods by which either a rotative or alternating motion may be produced by very moderate degrees of heat. If a ſtraight glaſs tube, ſuch as are uſed for barometers, be ſuſpended horizontally before a fire, like a roaſting ſpit, it will revolve by intervals; for as glaſs is a bad conductor of heat the ſide next the fire becomes heated ſooner than the oppoſite ſide, and the tube becomes bent into a bow with the external part of the curve towards the fire, this curve then falls down and produces a fourth part of a revolution of the glaſs tube, which thus revolves with intermediate pauſes.

Another alternating motion I have ſeen produced by ſuſpending a glaſs tube about eight inches long with bulbs at each end on a centre like a ſcale beam. This curious machine is filled about one third part with pureſt ſpirit of wine, the other two thirds being a vacuum, and is called a pulſe-glaſs, if it be placed in a box before the fire, ſo that either bulb, as it riſes, may become ſhaded from the fire, and expoſed to it when it deſcends, an alternate libration of it is produced. For ſpirit of wine in vacuo emits ſteam by a very ſmall degree of heat, and this ſteam forces the ſpirit beneath it up into the upper bulb, which therefore deſcends. It is probable ſuch a machine on a larger ſcale might be of uſe to open the doors or windows of hot-houſes or mellon-frames, when the air within them ſhould become too much heated, or might be employed in more important mechanical purpoſes.

On travelling through a hot ſummer's day in a chaiſe with a box covered with leather on the fore-axle-tree, I obſerved, as the ſun ſhone upon the black leather, the box began to open its lid, which at noon roſe above a foot, and could not without great force be preſſed down; and which gradually cloſed again as the ſun declined in the evening. This I ſuppoſe might with ſtill greater facility be applied to the purpoſe of opening melon-frames or the ſaſhes of hot-houſes.

The ſtatue of Memnon was overthrown and ſawed in two by Cambyſes to diſcover its internal ſtructure, and is ſaid ſtill to exiſt. See Savary's Letters on Egypt. The truncated ſtatue is ſaid for many centuries to have ſaluted the riſing ſun with chearful tones, and the ſetting ſun with melancholy ones.

NOTE IX.——LUMINOUS INSECTS.

Star of the earth, and diamond of the night. CANTO I. l. 192.

THERE are eighteen ſpecies of Lampyris or glow-worm, according to Linneus, ſome of which are found in almoſt every part of the world. In many of the ſpecies the females have no wings, and are ſuppoſed to be diſcovered by the winged males by their ſhining in the night. They become much more lucid when they put themſelves in motion, which would ſeem to indicate that their light is owing to their reſpiration; in which proceſs it is probable phoſphoric acid is produced by the combination of vital air with ſome part of the blood, and that light is given out through their tranſparent bodies by this ſlow internal combuſtion.

There is a fire-fly of the beetle-kind deſcribed in the Dict. Raiſonné under the name of Acudia, which is ſaid to be two inches long, and inhabits the Weſt-Indies and South America; the natives uſe them inſtead of candles, putting from one to three of them under a glaſs. Madam Merian ſays, that at Surinam the light of this fly is ſo great, that ſhe ſaw ſufficiently well by one of them to paint and finiſh one of the figures of them in her work on inſects. The largeſt and oldeſt of them are ſaid to become four inches long, and to ſhine like a ſhooting ſtar as they fly, and are thence called Lantern-bearers. The uſe of this light to the inſect itſelf ſeems to be that it may not fly againſt objects in the night; by which contrivance theſe inſects are enabled to procure their ſuſtenance either by night or day, as their wants may require, or their numerous enemies permit them; whereas ſome of our beetles have eyes adapted only to the night, and if they happen to come abroad too ſoon in the evening are ſo dazzled that they fly againſt every thing in their way. See note on Phoſphorus, No. X.

In ſome ſeas, as particularly about the coaſt of Malabar, as a ſhip floats along, it ſeems during the night to be ſurrounded with fire, and to leave a long tract of light behind it. Whenever the ſea is gently agitated it ſeems converted into little ſtars, every drop as it breaks emits light, like bodies electrified in the dark. Mr. Bomare ſays, that when he was at the port of Cettes in Languedoc, and bathing with a companion in the ſea after a very hot day, they both appeared covered with fire after every immerſion, and that laying his wet hand on the arm of his companion, who had not then dipped himſelf, the exact mark of his hand and fingers was ſeen in characters of fire. As numerous microſcopic inſects are found in this ſhining water, its light has been generally aſcribed to them, though it ſeems probable that fiſh-ſlime in hot countries may become in ſuch a ſtate of incipient putrefaction as to give light, eſpecially when by agitation it is more expoſed to the air; otherwiſe it is not eaſy to explain why agitation ſhould be neceſſary to produce this marine light. See note on Phoſphorus No. X.

NOTE X.——PHOSPHORUS.

Or mark in ſhining letters Kunckel's name
In the pale phoſphor's ſelf-conſuming flame. CANTO I. l. 237.

KUNCKEL, a native of Hamburgh, was the firſt who diſcovered to the world the proceſs for producing phoſphorus; though Brandt and Boyle were likewiſe ſaid to have previouſly had the art of making it. It was obtained from ſal microcoſmicum by evaporation in the form of an acid, but has ſince been found in other animal ſubſtances, as in the aſhes of bones, and even in ſome vegetables, as in wheat flour. Keir's chemical Dict. This phoſphoric acid is like all other acids united with vital air, and requires to be treated with charcoal or phlogiſton to deprive it of this air, it then becomes a kind of animal ſulphur, but of ſo inflammable a nature, that on the acceſs of air it takes fire ſpontaneouſly, and as it burns becomes again united with vital air, and re-aſſumes its form of phoſphoric acid.

As animal reſpiration ſeems to be a kind of ſlow combuſtion, in which it is probable that phoſphoric acid is produced by the union of phoſphorus with the vital air, ſo it is alſo probable that phoſphoric acid is produced in the excretory or reſpiratory veſſels of luminous inſects, as the glow-worm and fire-fly, and ſome marine inſects. From the ſame principle I ſuppoſe the light from putrid fiſh, as from the heads of hadocks, and from putrid veal, and from rotten wood in a certain ſtate of their putrefaction, is produced, and phoſphorus thus ſlowly combined with air is changed into phoſphoric acid. The light from the Bolognian ſtone, and from calcined ſhells, and from white paper, and linen after having been expoſed for a time to the ſun's light, ſeem to produce either the phoſphoric or ſome other kind of acid from the ſulphurous or phlogiſtic matter which they contain. See note on Beccari's ſhells. l. 180.

There is another proceſs ſeems ſimilar to this ſlow combuſtion, and that is *bleaching*. By the warmth and light of the ſun the water ſprinkled upon linen or cotton cloth ſeems to be decompoſed, (if we credit the theory of M. Lavoiſier,) and a part of the vital air thus ſet at liberty and uncombined and not being in its elaſtic form, more eaſily diſſolves the colouring or phlogiſtic matter of the cloth, and produces a new acid, which is itſelf colourleſs, or is waſhed out of the cloth by water. The new proceſs of bleaching confirms a part of this theory, for by uniting much vital air to marine acid by diſtilling it from mangancſe, on dipping the cloth to be bleached in water repleat with this ſuperaerated marine acid, the colouring matter diſappears immediately, ſooner indeed in cotton than in linen. See note XXXIV.

There is another proceſs which I ſuſpect bears analogy to theſe above-mentioned, and that is the rancidity of animal fat, as of bacon; if bacon be hung up in a warm kitchen, with much ſalt adhering on the outſide of it, the fat part of it ſoon becomes

yellow and rancid; if it be washed with much cold water after it has imbibed the salt, and just before it is hung up, I am well informed, that it will not become rancid, or in very slight degrees. In the former case I imagine the salt on the surface of the bacon attracts water during the cold of the night, which is evaporated during the day, and that in this evaporation a part of the water becomes decomposed; as in bleaching, and its vital air uniting with greater facility in its unelastic state with the animal fat, produces an acid, perhaps of the phosphoric kind, which being of a fixed nature lies upon the bacon, giving it the yellow colour and rancid taste. It is remarkable that the super-aerated marine acid does not bleach living animal substances, at least it did not whiten a part of my hand which I for some minutes exposed to it.

NOTE XI.——STEAM-ENGINE.

Quick moves the balanced beam, of giant-birth,
Wields his large limbs, and nodding shakes the earth. CANTO I. l. 267.

THE expansive force of steam was known in some degree to the antients, Hero of Alexandria describes an application of it to produce a rotative motion by the re-action of steam issuing from a sphere mounted upon an axis, through two small tubes bent into tangents, and issuing from the opposite sides of the equatorial diameter of the sphere, the sphere was supplied with steam by a pipe communicating with a pan of boiling water, and entering the sphere at one of its poles.

A french writer about the year 1630 describes a method of raising water to the upper part of a house by filling a chamber with steam, and suffering it to condense of itself, but it seems to have been mere theory, as his method was scarcely practicable as he describes it. In 1655 the Marquis of Worcester mentions a method of raising water by fire in his Century of Inventions, but he seems only to have availed himself of the expansive force and not to have known the advantages arising from condensing the steam by an injection of cold water. This latter and most important improvement seems to have been made by Capt. Savery sometime prior to 1698, for in that year his patent for the use of that invention was confirmed by act of parliament. This gentleman appears to have been the first who reduced the machine to practice and exhibited it in an useful form. This method consisted only in expelling the air from a vessel by steam and condensing the steam by an injection of cold water, which making a vacuum, the pressure of the atmosphere forced the water to ascend into the steam-vessel through a pipe of 24 to 26 feet

high, and by the admiſſion of denſe ſteam from the boiler, forcing the water in the ſteam-veſſel to aſcend to the height deſired. This conſtruction was defective becauſe it required very ſtrong veſſels to reſiſt the force of the ſteam, and becauſe an enormous quantity of ſteam was condenſed by coming in contact with the cold water in the ſteam-veſſel.

About or ſoon after that time M. Papin attempted a ſteam-engine on ſimilar principles but rather more defective in its conſtruction.

The next improvement was made very ſoon afterwards by Meſſrs. Newcomen and Cawley of Dartmouth, it conſiſted in employing for the ſteam-veſſel a hollow cylinder, ſhut at bottom and open at top, furniſhed with a piſton ſliding eaſily up and down in it, and made tight by oakum or hemp, and covered with water. This piſton is ſuſpended by chains from one end of a beam, moveable upon an axis in the middle of its length, to the other end of this beam are ſuſpended the pump-rods.

The danger of burſting the veſſels was avoided in this machine, as however high the water was to be raiſed it was not neceſſary to increaſe the denſity of the ſteam but only to enlarge the diameter of the cylinder.

Another advantage was, that the cylinder not being made ſo cold as in Savary's method, much leſs ſteam was loſt in filling it after each condenſation.

The machine however ſtill remained imperfect, for the cold water thrown into the cylinder acquired heat from the ſteam it condenſed, and being in a veſſel exhauſted of air it produced ſteam itſelf, which in part reſiſted the action of the atmoſphere on the piſton; were this remedied by throwing in more cold water the deſtruction of ſteam in the next filling of the cylinder would be proportionally increaſed. It has therefore in practice been found adviſeable not to load theſe engines with columns of water weighing more than ſeven pounds for each ſquare inch of the area of the piſton. The bulk of water when converted into ſteam remained unknown until Mr. J. Watt, then of Glaſgow, in 1764, determined it to be about 1800 times more rare than water. It ſoon occurred to Mr. Watt that a perfect engine would be that in which no ſteam ſhould be condenſed in filling the cylinder, and in which the ſteam ſhould be ſo perfectly cooled as to produce nearly a perfect vacuum.

Mr. Watt having aſcertained the degree of heat in which water boiled in vacuo, and under progreſſive degrees of preſſure, and inſtructed by Dr. Black's diſcovery of latent heat, having calculated the quantity of cold water neceſſary to condenſe certain quantities of ſteam ſo far as to produce the exhauſtion required, he made a communication from the cylinder to a cold veſſel previouſly exhauſted of air and water, into which the ſteam ruſhed by its elaſticity, and became immediately condenſed. He then adapted a cover to the cylinder and admitted ſteam above the piſton to preſs it down inſtead of air, and inſtead of applying water he uſed oil or greaſe to fill the pores of the oakum and to lubricate the cylinder.

He next applied a pump to extract the injection water, the condenſed ſteam, and the air, from the condenſing veſſel, every ſtroke of the engine.

To prevent the cooling of the cylinder by the contact of the external air, he surrounded it with a case containing steam, which he again protected by a covering of matters which conduct heat slowly.

This construction presented an easy means of regulating the power of the engine, for the steam being the acting power, as the pipe which admits it from the boiler is more or less opened, a greater or smaller quantity can enter during the time of a stroke, and consequently the engine can act with exactly the necessary degree of energy.

Mr. Watt gained a patent for his engine in 1768, but the further persecution of his designs were delayed by other avocations till 1775, when in conjunction with Mr. Boulton of Soho near Birmingham, numerous experiments were made on a large scale by their united ingenuity, and great improvements added to the machinery, and an act of parliament obtained for the prolongation of their patent for twenty-five years, they have since that time drained many of the deep mines in Cornwall, which but for the happy union of such genius must immediately have ceased to work. One of these engines works a pump of eighteen inches diameter, and upwards of 100 fathom or 600 feet high, at the rate of ten to twelve strokes of seven feet long each, in a minute, and that with one fifth part of the coals which a common engine would have taken to do the same work. The power of this engine may be easier comprehended by saying that it raised a weight equal to 81000 pounds 80 feet high in a minute, which is equal to the combined action of 200 good horses. In Newcomen's engine this would have required a cylinder of the enormous diameter of 120 inches or ten feet, but as in this engine of Mr. Watt and Mr. Boulton the steam acts, and a vacuum is made, alternately above and below the piston, the power exerted is double to what the same cylinder would otherways produce, and is further augmented by an inequality in the length of the two ends of the lever.

These gentlemen have also by other contrivances applied their engines to the turning of mills for almost every purpose, of which that great pile of machinery the Albion Mill is a well known instance. Forges, slitting mills, and other great works are erected where nature has furnished no running water, and future times may boast that this grand and useful engine was invented and perfected in our own country.

Since the above article went to the press the Albion Mill is no more; it is supposed to have been set on fire by interested or malicious incendaries, and is burnt to the ground. Whence London has lost the credit and the advantage of possessing the most powerful machine in the world!

NOTE XII.——FROST.

In phalanx firm the fiend of Froſt aſſail. CANTO I. l. 446.

THE cauſe of the expanſion of water during its converſion into ice is not yet well aſcertained, it was ſuppoſed to have been owing to the air being ſet at liberty in the act of congelation which was before diſſolved in the water, and the many air bubbles in ice were thought to countenance this opinion. But the great force with which ice expands during its congelation, ſo as to burſt iron bombs and coehorns, according to the experiments of Major Williams at Quebec, invalidates this idea of the cauſe of it, and may ſometime be brought into uſe as a means of breaking rocks in mining, or projecting cannon-balls, or for other mechanical purpoſes, if the means of producing congelation ſhould ever be diſcovered to be as eaſy as the means of producing combuſtion.

Mr. de Mairan attributes the increaſe of bulk of frozen water to the different arrangement of the particles of it in cryſtallization, as they are conſtantly joined at an angle of 60 degrees; and muſt by this diſpoſition he thinks occupy a greater volume than if they were parallel. He found the augmentation of the water during freezing to amount to one-fourteenth, one-eighteenth, one-nineteenth, and when the water was previouſly purged of air to only one-twenty-ſecond part. He adds that a piece of ice, which was at firſt only one-fourteenth part ſpecifically lighter than water, on being expoſed ſome days to the froſt became one-twelfth lighter than water. Hence he thinks ice by being expoſed to greater cold ſtill increaſes in volume, and to this attributes the burſting of ice in ponds and on the glaciers. See Lewis's Commerce of Arts, p. 257. and the note on Muſchus in the other volume of this work.

This expanſion of ice well accounts for the greater miſchief done by vernal froſts attended with moiſture, (as by hoar-froſts,) than by the dry froſts called black froſts. Mr. Lawrence in a letter to Mr. Bradley complains that the dale-miſt attended with a froſt on may-day had deſtroyed all his tender fruits; though there was a ſharper froſt the night before without a miſt, that did him no injury; and adds, that a garden not a ſtone's throw from his own on a higher ſituation, being above the dale-miſt, had received no damage. Bradley, Vol. II. p. 232.

Mr. Hunter by very curious experiments diſcovered that the living principle in fiſh, in vegetables, and even in eggs and ſeeds, poſſeſſes a power of reſiſting congelation. Phil. Tranſ. There can be no doubt but that the exertions of animals to avoid the pain of cold may produce in them a greater quantity of heat, at leaſt for a time, but that vegetables, eggs, or ſeeds, ſhould poſſeſs ſuch a quality is truly wonderful. Others have imagined that animals poſſeſs a power of preventing themſelves from becoming much warmer than 98 degrees of heat, when immerſed in an atmoſphere above that degree of heat. It is true that the increaſed exhalation from their bodies will in ſome meaſure cool them, as much heat is carried off by the evaporation of fluids, but this is a chemical not an animal proceſs. The experiments made by thoſe who continued

many minutes in the air of a room heated ſo much above any natural atmoſpheric heat, do not ſeem concluſive, as they remained in it a leſs time than would have been neceſſary to have heated a maſs of beef of the ſame magnitude, and the circulation of the blood in living animals, by perpetually bringing new ſupplies of fluid to the ſkin, would prevent the external ſurface from becoming hot much ſooner than the whole maſs. And thirdly, there appears no power of animal bodies to produce cold in diſeaſes, as in ſcarlet fever, in which the increaſed action of the veſſels of the ſkin produces heat and contributes to exhauſt the animal power already too much weakened.

It has been thought by many that froſts meliorate the ground, and that they are in general ſalubrious to mankind. In reſpect to the former it is now well known that ice or ſnow contain no nitrous particles, and though froſt by enlarging the bulk of moiſt clay leaves it ſofter for a time after the thaw, yet as ſoon as the water exhales, the clay becomes as hard as before, being preſſed together by the incumbent atmoſphere, and by its ſelf-attraction, called *ſetting* by the potters. Add to this that on the coaſts of Africa, where froſt is unknown, the fertility of the ſoil is almoſt beyond our conceptions of it. In reſpect to the general ſalubrity of froſty ſeaſons the bills of mortality are an evidence in the negative, as in long froſts many weakly and old people periſh from debility occaſioned by the cold, and many claſſes of birds and other wild animals are benumbed by the cold or deſtroyed by the conſequent ſcarcity of food, and many tender vegetables periſh from the degree of cold.

I do not think it ſhould be objected to this doctrine that there are moiſt days attended with a briſk cold wind when no viſible ice appears, and which are yet more diſagreeable and deſtructive than froſty weather. For on theſe days the cold moiſture, which is depoſited on the ſkin is there evaporated and thus produces a degree of cold perhaps greater than the milder froſts. Whence even in ſuch days both the diſagreeable ſenſations and inſalubrious effects belong to the cauſe abovementioned, viz. the intenſity of the cold. Add to this that in theſe cold moiſt days as we paſs along or as the wind blows upon us, a new ſheet of cold water is as it were perpetually applied to us and hangs upon our bodies, now as water is 800 times denſer than air and is a much better conductor of heat, we are ſtarved with cold like thoſe who go into a cold bath, both by the great number of particles in contact with the ſkin and their greater facility of receiving our heat.

It may nevertheleſs be true that ſnows of long duration in our winters may be leſs injurious to vegetation than great rains and ſhorter froſts, for two reaſons. 1. Becauſe great rains carry down many thouſand pounds worth of the beſt part of the manure off the lands into the ſea, whereas ſnow diſſolves more gradually and thence carries away leſs from the land; any one may diſtinguiſh a ſnow-flood from a rain-flood by the tranſparency of the water. Hence hills or fields with conſiderable inclination of ſurface ſhould be ploughed horizontally that the furrows may ſtay the water from ſhowers till it depoſits its mud. 2. Snow protects vegetables from the ſeverity of the froſt, ſince it is always in a ſtate of thaw where it is in contact with the earth; as the earth's heat is about 48° and the heat of thawing ſnow is 32° the vegetables between them are kept in a degree of heat about 40, by which many of them are preſerved. See note on Muſchus, Vol. I. of this work.

NOTE XIII.—ELECTRICITY.

Cold from each point cerulean lustres gleam. CANTO I. l. 345.

ELECTRIC POINTS.

THERE was an idle dispute whether knobs or points were preferable on the top of conductors for the defence of houses. The design of these conductors is to permit the electric matter accumulated in the clouds to pass through them into the earth in a smaller continued stream as the cloud approaches, before it comes to what is termed striking distance; now as it is well known that accumulated electricity will pass to points at a much greater distance than it will to knobs there can be no doubt of their preference; and it would seem that the finer the point and the less liable to become rusty the better, as it would take off the lightening while it was still at a greater distance, and by that means preserve a greater extent of building; the very extremity of the point should be of pure silver or gold, and might be branched into a kind of brush, since one small point can not be supposed to receive so great a quantity as a thicker bar might conduct into the earth.

If an insulated metallic ball is armed with a point, like a needle, projecting from one part of it, the electric fluid will be seen in the dark to pass off from this point, so long as the ball is kept supplied with electricity. The reason of this is not difficult to comprehend, every part of the electric atmosphere which surrounds the insulated ball is attracted to that ball by a large surface of it, whereas the electric atmosphere which is near the extremity of the needle is attracted to it by only a single point, in consequence the particles of electric matter near the surface of the ball approach towards it and push off by their greater gravitation the particles of electric matter over the point of the needle in a continued stream.

Something like this happens in respect to the diffusion of oil on water from a pointed cork, an experiment which was many years ago shewn me by Dr. Franklin; he cut a piece of cork about the size of a letter-wafer and left on one edge of it a point about a sixth of an inch in length projecting as a tangent to the circumference. This was dipped in oil and thrown on a pond of water and continued to revolve as the oil left the point for a great many minutes. The oil descends from the floating cork upon the water being diffused upon it without friction and perhaps without contact; but its going off at the point so forcibly as to make the cork revolve in a contrary direction seems analogous to the departure of the electric fluid from points.

Can any thing similar to either of these happen in respect to the earth's atmosphere and give occasion to the breezes on the tops of mountains, which may be considered as points on the earths circumference?

FAIRY-RINGS.

There is a phenomenon fuppofed to be electric which is yet unaccounted for, I mean the Fairy-rings, as they are called, fo often feen on the grafs. The numerous flafhes of lightning which occur every fummer are, I believe, generally difcharged on the earth, and but feldom (if ever) from one cloud to another. Moift trees are the moft frequent conductors of thefe flafhes of lightning, and I am informed by purchafers of wood that innumerable trees are thus cracked and injured. At other times larger parts or prominences of clouds gradually finking as they move along, are difcharged on the moifture parts of graffy plains. Now this knob or corner of a cloud in being attracted by the earth will become nearly cylindrical, as loofe wool would do when drawn out into a thread, and will ftrike the earth with a ftream of electricity perhaps two or ten yards in diameter. Now as a ftream of electricity difplaces the air it paffes through, it is plain no part of the grafs can be burnt by it, but juft the external ring of this cylinder where the grafs can have accefs to the air, fince without air nothing can be calcined. This earth after having been fo calcined becomes a richer foil, and either fungufes or a bluer grafs for many years mark the place. That lightning difplaces the air in its paffage is evinced by the loud crack that fucceeds it, which is owing to the fides of the aerial vacuum clapping together when the lightning is withdrawn. That nothing will calcine without air is now well underftood from the acids produced in the burning of phlogiftic fubftances, and may be agreeably feen by fufpending a paper on an iron prong and putting it into the centre of the blaze of an iron-furnace; it may be held there fome feconds and may be again withdrawn without its being burnt, if it be paffed quickly into the flame and out again through the external part of it which is in contact with the air. I know fome circles of many yards diameter of this kind near Foremark in Derbyfhire which annually produce large white fungufes and ftronger grafs, and have done fo, I am informed, above thirty years. This increafed fertility of the ground by calcination or charring, and its continuing to operate fo many years is well worth the attention of the farmer, and fhews the ufe of paring and burning new turf in agriculture, which produces its effect not fo much by the afhes of the vegetable fibres as by charring the foil which adheres to them.

Thefe fituations, whether from eminence or from moifture, which were proper once to attract and difcharge a thunder-cloud, are more liable again to experience the fame. Hence many fairy-rings are often feen near each other either without interfecting each other, as I faw this fummer in a garden in Nottinghamfhire, or interfecting each other as defcribed on Arthur's feat near Edinburgh in the Edinb. Tranf. Vol. II. p. 3.

NOTE XIV.——BUDS AND BULBS.

Where dwell my vegetative realms benumb'd
In buds impriſon'd, or in bulbs intomb'd. CANTO I. l. 465.

A TREE is properly ſpeaking a family or ſwarm of buds, each bud being an individual plant, for if one of theſe buds be torn or cut out and planted in the earth with a glaſs cup inverted over it to prevent its exhalation from being at firſt greater than its power of abſorption, it will produce a tree ſimilar to its parent; each bud has a leaf, which is its lungs, appropriated to it, and the bark of the tree is a congeries of the roots of theſe individual buds, whence old hollow trees are often ſeen to have ſome branches flouriſh with vigour after the internal wood is almoſt intirely decayed and vaniſhed. According to this idea Linneus has obſerved that trees and ſhrubs are roots above ground, for if a tree be inverted leaves will grow from the root-part and roots from the trunk-part. Phil. Bot. p. 39. Hence it appears that vegetables have two methods of propagating themſelves, the oviparous as by ſeeds, and the viviparous as by their buds and bulbs, and that the individual plants, whether from ſeeds or buds or bulbs, are all annual productions like many kinds of inſects as the ſilk-worm, the parent periſhing in the autumn after having produced an embryon, which lies in a torpid ſtate during the winter, and is matured in the ſucceeding ſummer. Hence Linneus names buds and bulbs the winter-cradles of the plant or hybernacula, and might have given the ſame term to ſeeds. In warm climates few plants produce buds, as the vegetable life can be compleated in one ſummer, and hence the hybernacle is not wanted; in cold climates alſo ſome plants do not produce buds, as philadelphus, frangula, viburnum, ivy, heath, wood-nightſhade, rue, geranium.

The bulbs of plants are another kind of winter-cradle, or hybernacle, adhering to the deſcending trunk, and are found in the perennial herbaceous plants which are too tender to bear the cold of the winter. The production of theſe ſubterraneous winter lodges, is not yet perhaps clearly underſtood, they have been diſtributed by Linneus according to their forms into ſcaly, ſolid, coated, and jointed bulbs, which however does not elucidate their manner of production. As the buds of trees may be truly eſteemed individual annual plants, their roots conſtituting the bark of the tree, it follows that theſe roots (viz. of each individual bud) ſpread themſelves over the laſt years bark, making a new bark over the old one, and thence deſcending cover with a new bark the old roots alſo in the ſame manner. A ſimilar circumſtance I ſuppoſe to happen in ſome herbaceous plants, that is, a new bark is annually produced over the old root, and thus for ſome years at leaſt the old root or caudex increaſes in ſize and puts up new ſtems. As theſe roots increaſe in ſize the central part I ſuppoſe changes like the internal wood of a tree and does not poſſeſs any vegetable life, and therefore gives out no fibres or rootlets, and hence appears bitten off, as in valerian, plantain, and devil's-bit. And this decay of the central part of the root I ſuppoſe has given occaſion to the belief of the root-fibres drawing down the bulb ſo much inſiſted on by Mr. Milne in his Botanical Dictionary, Art. Bulb.

From the obſervations and drawings of various kinds of bulbous roots at different times of their growth, ſent me by a young lady of nice obſervation, it appears probable that all bulbous roots properly ſo called periſh annually in this climate: Bradley, Miller, and the Author of Spectacle de la Nature, obſerve that the tulip annually renews its bulb, for the ſtalk of the old flower is found under the old dry coat but on the outſide of the new bulb. This large new bulb is the flowering bulb, but beſides this there are other ſmall new bulbs produced between the coats of this large one but from the ſame caudex, (or circle from which the root-fibres ſpring;) theſe ſmall bulbs are leaf-bearing bulbs, and renew themſelves annually with increaſing ſize till they bear flowers.

Miſs ——— favoured me with the following curious experiment: She took a ſmall tulip-root out of the earth when the green leaves were ſufficiently high to ſhow the flower, and placed it in a glaſs of water; the leaves and flower ſoon withered and the bulb became wrinkled and ſoft, but put out one ſmall ſide bulb and three bulbs beneath deſcending an inch into the water by long proceſſes from the caudex, the old bulb in ſome weeks intirely decayed; on diſſecting this monſter, the middle deſcending bulb was found by its proceſs to adhere to the caudex and to the old flower-ſtem, and the ſide ones were ſeparated from the flower-ſtem by a few ſhrivelled coats, but adhered to the caudex. Whence ſhe concludes that theſe laſt were off-ſets or leaf-bulbs which ſhould have been ſeen between the coats of the new flower-bulb if it had been left to grow in the earth, and that the middle one would have been the new flower-bulb. In ſome years (perhaps in wet ſeaſons) the floriſts are ſaid to loſe many of their tulip-roots by a ſimilar proceſs, the new leaf-bulbs being produced beneath the old ones by an elongation of the caudex without any new flower-bulbs.

By repeated diſſections ſhe obſerves that the leaf-bulbs or off-ſets of tulip, crocus, gladiolus, fritillary, are renewed in the ſame manner as the flowering-bulbs, contrary to the opinion of many writers; this new leaf-bulb is formed on the inſide of the coats from whence the leaves grow, and is more or leſs advanced in ſize as the outer coats and leaves are more or leſs ſhrivelled. In examining tulip, iris, hyacinth, hare-bell, the new bulb was invariably found *between* the flower-ſtem and the baſe of the innermoſt leaf of thoſe roots which had flowered, and *incloſed by* the baſe of the innermoſt leaf in thoſe roots which had not flowered, in both caſes adhering to the caudex or fleſhy circle from which the root-fibres ſpring.

Hence it is probable that the bulbs of hyacinths are renewed annually, but that this is performed from the caudex within the old bulb, the outer coat of which does not ſo ſhrivel as in crocus and fritillary and hence this change is not ſo apparent. But I believe as ſoon as the flower is advanced the new bulbs may be ſeen on diſſection, nor does the annual increaſe of the ſize of the root of cyclamen and of aletris capenſis militate againſt this annual renewal of them, ſince the leaf-bulbs or off-ſets, as deſcribed above, are increaſed in ſize as they are annually renewed. See note on orchis, and on anthoxanthum, in Vol. II. of this work.

NOTE XV.—SOLAR VOLCANOS.

From the deep craters of his realms of fire
The whirling sun this ponderous planet hurl'd. CANTO II. l. 14.

DR. ALEXANDER WILSON, Professor of Astronomy at Glasgow, published a paper in the Philosophical Transactions for 1774, demonstrating that the spots in the sun's disk are real cavities, excavations through the luminous material, which covers the other parts of the sun's surface. One of these cavities he found to be about 4000 miles deep and many times as wide. Some objections were made to this doctrine by M. De la Laude in the Memoirs of the French Academy for the year 1776, which however have been ably answered by Professor Wilson in reply in the Philos. Trans. for 1783. Keil observes, in his Astronomical Lectures, p. 44, "We frequently see spots in the sun which are larger and broader not only than Europe or Africa, but which even equal, if they do not exceed, the surface of the whole terraqueous globe." Now that these cavities are made in the sun's body by a process of nature similar to our earthquakes does not seem improbable on several accounts. 1. Because from this discovery of Dr. Wilson it appears that the internal parts of the sun are not in a state of inflammation or of ejecting light, like the external part or luminous ocean which covers it; and hence that a greater degree of heat or inflammation and consequent expansion or explosion may occasionally be produced in its internal or dark nucleus. 2. Because the solar spots or cavities are frequently increased or diminished in size. 3. New ones are often produced. 4. And old ones vanish. 5. Because there are brighter or more luminous parts of the sun's disk, called faculæ by Scheiner and Hevelius, which would seem to be volcanos in the sun, or, as Dr. Wilson calls them, "eructations of matter more luminous than that which covers the sun's surface." 6. To which may be added that all the planets added together with their satellites do not amount to more than one six hundred and fiftieth part of the mass of the sun according to Sir Isaac Newton.

Now if it could be supposed that the planets were originally thrown out of the sun by larger sun-quakes than those frequent ones which occasion these spots or excavations above-mentioned, what would happen? 1. According to the observations and opinion of Mr. Herschel the sun itself and all its planets are moving forwards round some other centre with an unknown velocity, which may be of opake matter corresponding with the very antient and general idea of a chaos. Whence if a ponderous planet, as Saturn, could be supposed to be projected from the sun by an explosion, the motion of the sun itself might be at the same time disturbed in such a manner as to prevent the planet from falling again into it. 2. As the sun revolves round its own axis its form must be that of an oblate spheroid like the earth, and therefore a body projected from its surface perpendicularly upwards from that surface would not rise perpendicularly from the sun's centre, unless it happened to be projected exactly from either of its poles or

from its equator. Whence it may not be neceſſary that a planet if thus projected from the ſun by exploſion ſhould again fall into the ſun. 3. They would part from the ſun's ſurface with the velocity with which that ſurface was moving, and with the velocity acquired by the exploſion, and would therefore move round the ſun in the ſame direction in which the ſun rotates on its axis, and perform eliptic orbits. 4. All the planets would move the ſame way round the ſun, from this firſt motion acquired at leaving its ſurface, but their orbits would be inclined to each other according to the diſtance of the part, where they were thrown out, from the ſun's equator. Hence thoſe which were ejected near the ſun's equator would have orbits but little inclined to each other, as the primary planets; the plain of all whoſe orbits are inclined but ſeven degrees and a half from each other. Others which were ejected near the ſun's poles would have much more eccentric orbits, as they would partake ſo much leſs of the ſun's rotatory motion at the time they parted from his ſurface, and would therefore be carried further from the ſun by the velocity they had gained by the exploſion which ejected them, and become comets. 5. They would all obey the ſame laws of motion in their revolutions round the ſun; this has been determined by aſtronomers, who have demonſtrated that they move through equal areas in equal times. 6. As their annual periods would depend on the height they roſe by the exploſion, theſe would differ in them all. 7. As their diurnal revolutions would depend on one ſide of the exploded matter adhering more than the other at the time it was torn off by the exploſion, theſe would alſo differ in the different planets, and not bear any proportion to their annual periods. Now as all theſe circumſtances coincide with the known laws of the planetary ſyſtem, they ſerve to ſtrengthen this conjecture.

This coincidence of ſuch a variety of circumſtances induced M. de Buffon to ſuppoſe that the planets were all ſtruck off from the ſun's ſurface by the impact of a large comet, ſuch as approached ſo near the ſun's diſk, and with ſuch amazing velocity, in the year 1680, and is expected to return in 2255. But Mr. Buffon did not recollect that theſe comets themſelves are only planets with more eccentric orbits, and that therefore it muſt be aſked, what had previouſly ſtruck off theſe comets from the ſun's body? 2. That if all theſe planets were ſtruck off from the ſun at the ſame time, they muſt have been ſo near as to have attracted each other and have formed one maſs: 3. That we ſhall want new cauſes for ſeparating the ſecondary planets from the primary ones, and muſt therefore look out for ſome other agent, as it does not appear how the impulſe of a comet could have made one planet roll round another at the time they both of them were driven off from the ſurface of the ſun.

If it ſhould be aſked, why new planets are not frequently ejected from the ſun? it may be anſwered, that after many large earthquakes many vents are left for the elaſtic vapours to eſcape, and hence, by the preſent appearance of the ſurface of our earth, earthquakes prodigiouſly larger than any recorded in hiſtory have exiſted; the ſame circumſtances may have affected the ſun, on whoſe ſurface there are appearances of volcanos, as deſcribed above. Add to this, that ſome of the comets, and even the georgium ſidus, may, for ought we know to the contrary, have been emitted from the ſun in more

modern days, and have been diverted from their courſe, and thus prevented from returning into the ſun, by their approach to ſome of the older planets, which is ſomewhat countenanced by the opinion ſeveral philoſophers have maintained, that the quantity of matter of the ſun has decreaſed. Dr. Halley obſerved, that by comparing the proportion which the periodical time of the moon bore to that of the ſun in former times, with the proportion between them at preſent, that the moon is found to be ſomewhat accelerated in reſpect to the ſun. Pemberton's View of Sir Iſaac Newton, p. 247. And ſo large is the body of this mighty luminary, that all the planets thus thrown out of it would make ſcarcely any perceptible diminution of it, as mentioned above. The cavity mentioned above, as meaſured by Dr. Wilſon of 4000 miles in depth, not penetrating an hundredth part of the ſun's ſemi-diameter; and yet, as its width was many times greater than its depth, was large enough to contain a greater body than our terreſtrial world.

I do not mean to conceal, that from the laws of gravity unfolded by Sir Iſaac Newton, ſuppoſing the ſun to be a ſphere and to have no progreſſive motion, and not liable itſelf to be diſturbed by the ſuppoſed projection of the planets from it, that ſuch planets muſt return into the ſun. The late Rev. William Ludlam, of Leiceſter, whoſe genius never met with reward equal to its merits, in a letter to me, dated January, 1787, after having ſhewn, as mentioned above, that planets ſo projected from the ſun would return to it, adds, "That a body as large as the moon ſo projected, would diſturb the motion of the "earth in its orbit, is certain; but the calculation of ſuch diſturbing forces is difficult. "The body in ſome circumſtances might become a ſatellite, and both move round their "common centre of gravity, and that centre be carried in an annual orbit round the "ſun."

There are other circumſtances which might have concurred at the time of ſuch ſuppoſed exploſions, which would render this idea not impoſſible. 1. The planets might be thrown out of the ſun at the time the ſun itſelf was riſing from chaos, and be attracted by other ſuns in their vicinity riſing at the ſame time out of chaos, which would prevent them from returning into the ſun. 2. The new planet in its courſe or aſcent from the ſun, might explode and eject a ſatellite, or perhaps more than one, and thus by its courſe being affected might not return into the ſun. 3. If more planets were ejected at the ſame time from the ſun, they might attract and diſturb each others courſe at the time they left the body of the ſun, or very ſoon afterwards, when they would be ſo much nearer each other.

NOTE XVI.——CALCAREOUS EARTH.

While Ocean wrap'd it in his azure robe. CANTO II. l. 34.

FROM having obferved that many of the higheft mountains of the world confift of lime-ftone replete with fhells, and that thefe mountains bear the marks of having been lifted up by fubterraneous fires from the interior parts of the globe; and as lime-ftone replete with fhells is found at the bottom of many of our deepeft mines fome philofophers have concluded that the nucleus of the earth was for many ages covered with water which was peopled with its adapted animals; that the fhells and bones of thefe animals in a long feries of time produced folid ftrata in the ocean furrounding the original nucleus.

Thefe ftrata confift of the accumulated exuviæ of fhell-fifh, the animals perifhed age after age but their fhells remained, and in progreffion of time produced the amazing quantities of lime-ftone which almoft cover the earth. Other marine animals called coralloids raifed walls and even mountains by the congeries of their calcareous habitations, thefe perpendicular corralline rocks make fome parts of the Southern Ocean highly dangerous, as appears in the journals of Capt. Cook. From contemplating the immenfe ftrata of lime-ftone, both in refpect to their extent and thicknefs, formed from thefe fhells of animals, philofophers have been led to conclude that much of the water of the fea has been converted into calcareous earth by paffing through their organs of digeftion. The formation of calcareous earth feems more particularly to be an animal procefs as the formation of clay belongs to the vegetable economy; thus the fhells of crabs and other teftaceous fifh are annually reproduced from the mucous membrane beneath them; the fhells of eggs are firft a mucous membrane, and the calculi of the kidneys and thofe found in all other parts of our fyftem which fometimes contain calcareous earth, feem to originate from inflamed membranes; the bones themfelves confift of calcareous earth united with the phofphoric or animal acid, which may be feparated by diffolving the afhes of calcined bones in the nitrous acid; the various fecretions of animals, as their faliva and urine, abound likewife with calcareous earth, as appears by the incruftations about the teeth and the fediments of urine. It is probable that animal mucus is a previous procefs towards the formation of calcareous earth; and that all the calcareous earth in the world which is feen in lime-ftones, marbles, fpars, alabafters, marls, (which make up the greateft part of the earth's cruft, as far as it has yet been penetrated,) have been formed originally by animal and vegetable bodies from the mafs of water, and that by thefe means the folid part of the terraqueous globe has perpetually been in an increafing ftate and the water perpetually in a decreafing one.

After the mountains of fhells and other recrements of aquatic animals were elevated above the water the upper heaps of them were gradually diffolved by rains and dews and oozing through were either perfectly cryftallized in fmaller cavities and formed

calcareous ſpar, or were imperfectly cryſtallized on the roofs of larger cavities and produced ſtalactites; or mixing with other undiſſolved ſhells beneath them formed marbles, which were more or leſs cryſtallized and more or leſs pure; or laſtly, after being diſſolved, the water was exhaled from them in ſuch a manner that the external parts became ſolid, and forming an arch prevented the internal parts from approaching each other ſo near as to become ſolid, and thus chalk was produced. I have ſpecimens of chalk formed at the root of ſeveral ſtalactites, and in their central parts; and of other ſtalactites which are hollow like quills from a ſimilar cauſe, viz. from the external part of the ſtalactite hardening firſt by its evaporation, and thus either attracting the internal diſſolved particles to the cruſt, or preventing them from approaching each other ſo as to form a ſolid body. Of theſe I ſaw many hanging from the arched roof of a cellar under the high ſtreet in Edinburgh.

If this diſſolved limeſtone met with vitriolic acid it was converted into alabaſter, parting at the ſame time with its fixable air. If it met with the fluor acid it became fluor; if with the ſiliceous acid, flint; and when mixed with clay and ſand, or either of them, acquires the name of marl. And under one or other of theſe forms compoſes a great part of the ſolid globe of the earth.

Another mode in which limeſtone appears is in the form of round granulated particles, but ſlightly cohering together; of this kind a bed extends over Lincoln heath, perhaps twenty miles long by ten wide. The form of this calcareous ſand, its angles having been rubbed off, and the flatneſs of its bed, evinces that that part of the country was ſo formed under water, the particles of ſand having thus been rounded, like all other rounded pebbles. This round form of calcareous ſand and of other larger pebbles is produced under water, partly by their being more or leſs ſoluble in water, and hence the angular parts become diſſolved, firſt, by their expoſing a larger ſurface to the action of the menſtruum, and ſecondly, from their attrition againſt each other by the ſtreams or tides, for a great length of time, ſucceſſively as they were collected, and perhaps when ſome of them had not acquired their hardeſt ſtate.

This calcareous ſand has generally been called ketton-ſtone and believed to reſemble the ſpawn of fiſh, it has acquired a form ſo much rounder than ſiliceous ſand from its being of ſo much ſofter a texture and alſo much more ſoluble in water. There are other ſoft calcareous ſtones called tupha which are depoſited from water on moſſes, as at Matlock, from which moſs it is probable the water may receive ſomething which induces it the readier to part with its earth.

In ſome lime-ſtones the living animals ſeem to have been buried as well as their ſhells during ſome great convulſion of nature, theſe ſhells contain a black coaly ſubſtance within them, in others ſome phlogiſton or volatile alcali from the bodies of the dead animals remains mixed with the ſtone, which is then called liver-ſtone as it emits a ſulphurous ſmell on being ſtruck, and there is a ſtratum about ſix inches thick extends a conſiderable way over the iron ore at Wingerworth near Cheſterfield in Derbyſhire which ſeems evidently to have been formed from the ſhells of freſh-water muſcles

There is however another source of calcareous earth besides the aquatic one above described and that is from the recrements of land animals and vegetables as found in marls, which consist of various mixtures of calcareous earth, sand, and clay, all of them perhaps principally from vegetable origin.

Dr. Hutton is of opinion that the rocks of marble have been softened by fire into a fluid mass, which he thinks under immense pressure might be done without the escape of their carbonic acid or fixed air. Edinb. Transact. Vol. I. If this ingenious idea be allowed it might account for the purity of some white marbles, as during their fluid state there might be time for their partial impurities, whether from the bodies of the animals which produced the shells or from other extraneous matter, either to sublime to the uppermost part of the stratum or to subside to the lowermost part of it. As a confirmation of this theory of Dr. Hutton's it may be added that some calcareous stones are found mixed with lime, and have thence lost a part of their fixed air or carbonic gas, as the bath-stone, and on that account hardens on being exposed to the air, and mixed with sulphur produces calcareous liver of sulphur. Falconer on Bath-water. Vol. I. p. 156. and p. 257. Mr. Monnet found lime in powder in the mountains of Auvergne, and suspected it of volcanic origin. Kirwan's Min. p. 22.

NOTE XVII.——MORASSES.

Gnomes! you then taught transuding dews to pass
Through time-fallen woods, and root-inwove morass. Canto II. l. 11

WHERE woods have repeatedly grown and perished morasses are in process of time produced, and by their long roots fill up the interstices till the whole becomes for many yards deep a mass of vegetation. This fact is curiously verified by an account given many years ago by the Earl of Cromartie, of which the following is a short abstract.

In the year 1651 the Earl of Cromartie being then nineteen years of age saw a plain in the parish of Lockburn covered over with a firm standing wood, which was so old that not only the trees had no green leaves upon them but the bark was totally thrown off, which he was there informed by the old countrymen was the universal manner in which fir-woods terminated, and that in twenty or thirty years the trees would cast themselves up by the roots. About fifteen years after he had occasion to travel the same way and observed that there was not a tree nor the appearance of a root of any of them; but in their place the whole plain where the wood stood was

covered with a flat green moſs or moraſs, and on aſking the country people what was become of the wood he was informed that no one had been at the trouble to carry it away, but that it had all been overturned by the wind, that the trees lay thick over each other, and that the moſs or bog had overgrown the whole timber, which they added was occaſioned by the moiſture which came down from the high hills above it and ſtagnated upon the plain, and that nobody could yet paſs over it, which however his Lordſhip was ſo incautious as to attempt and ſlipt up to the arm-pits. Before the year 1699 that whole piece of ground was become a ſolid moſs wherein the peaſants then dug turf or peat, which however was not yet of the beſt ſort. Philoſ. Tranſ. No. 330. Abridg. Vol. V. p. 272.

Moraſſes in great length of time undergo variety of changes, firſt by elutriation, and afterwards by fermentation, and the conſequent heat. 1. By water perpetually oozing through them the moſt ſoluble parts are firſt waſhed away, as the eſſential ſalts, theſe together with the ſalts from animal recrements are carried down the rivers into the ſea, where all of them ſeem to decompoſe each other except the marine ſalt. Hence the aſhes of peat contain little or no vegetable alcali and are not uſed in the countries, where peat conſtitutes the fuel of the lower people, for the purpoſe of waſhing linen. The ſecond thing which is always ſeen oozing from moraſſes is iron in ſolution, which produces chalybeate ſprings, from whence depoſitions of ochre and variety of iron ores. The third elutriation ſeems to conſiſt of vegetable acid, which by means unknown appears to be converted into all other acids. 1. Into marine and nitrous acids as mentioned above. 2. Into vitriolic acid which is found in ſome moraſſes ſo plentifully as to preſerve the bodies of animals from putrefaction which have been buried in them, and this acid carried away by rain and dews and meeting with calcareous earth produces gypſum or alabaſter, with clay it produces alum, and deprived of its vital air produces ſulphur. 3. Fluor acid which being waſhed away and meeting with calcareous earth produces fluor or cubic ſpar. 4. The ſiliceous acid which ſeems to have been diſſeminated in great quantity either by ſolution in water or by ſolution in air, and appears to have produced the ſand in the ſea uniting with calcareous earth previouſly diſſolved in that element, from which were afterwards formed ſome of the grit-ſtone rocks by means of a ſiliceous or calcareous cement. By its union with the calcareous earth of the moraſs other ſtrata of ſiliceous ſand have been produced; and by the mixture of this with clay and lime aroſe the beds of marl.

In other circumſtances, probably where leſs moiſture has prevailed, moraſſes ſeem to have undergone a fermentation, as other vegetable matter, new hay for inſtance is liable to do from the great quantity of ſugar it contains. From the great heat thus produced in the lower parts of immenſe beds of moraſs the phlogiſtic part, or oil, or aſphaltum, becomes diſtilled, and riſing into higher ſtrata becomes again condenſed forming coal-beds of greater or leſs purity according to their greater or leſs quantity of inflammable matter; at the ſame time the clay beds become purer or leſs ſo, as the phlogiſtic part is more or leſs completely exhaled from them. Though coal and clay are frequently produced in this manner, yet I have no doubt, but that they are likewiſe often produced by

elutriation; in ſituations on declivities the clay is waſhed away down into the valleys, and the phlogiſtic part or coal left behind; this circumſtance is ſeen in many valleys near the beds of rivers, which are covered recently by a whitiſh impure clay, called water-clay. See note XIX. XX. and XXIII.

LORD CROMARTIE has furniſhed another curious obſervation on moraſſes in the paper above referred to. In a moſs near the town of Eglin in Murray, though there is no river or water which communicates with the moſs, yet for three or four feet of depth in the moſs there are little ſhell-fiſh reſembling oyſters with living fiſh in them in great quantities, though no ſuch fiſh are found in the adjacent rivers, nor even in the water pits in the moſs, but only in the ſolid ſubſtance of the moſs. This curious fact not only accounts for the ſhells ſometimes found on the ſurface of coals, and in the clay above them; but alſo for a thin ſtratum of ſhells which ſometimes exiſts over iron-ore.

NOTE XVIII.——IRON.

Cold waves, immerged, the glowing maſs congeal,
And turn to adamant the hiſſing Steel. CANTO II. l. 191.

AS iron is formed near the ſurface of the earth, it becomes expoſed to ſtreams of water and of air more than moſt other metallic bodies, and thence becomes combined with oxygene, or vital air, and appears very frequently in its calciform ſtate, as in variety of ochres. Manganeſe, and zinc, and ſometimes lead, are alſo found near the ſurface of the earth, and on that account become combined with vital air and are exhibited in their calciform ſtate.

The avidity with which iron unites with oxygene, or vital air, in which proceſs much heat is given out from the combining materials, is ſhewn by a curious experiment of M. Ingenhouz. A fine iron wire twiſted ſpirally is fixed to a cork, on the point of the ſpire is fixed a match made of agaric dipped in ſolution of nitre; the match is then ignited, and the wire with the cork put immediately into a bottle full of vital air, the match firſt burns vividly, and the iron ſoon takes fire and conſumes with brilliant ſparks till it is reduced to ſmall brittle globules, gaining an addition of about one third of its weight by its union with vital air. Annales de Chymie. Traité de Chimie, per Lavoiſier, c. iii.

STEEL.

It is probably owing to a total deprivation of vital air which it holds with ſo great avidity, that iron on being kept many hours or days in ignited charcoal becomes converted into ſteel, and thence acquires the faculty of being welded when red hot long before it melts, and alſo the power of becoming hard when immerſed in cold water; both which I ſuppoſe depend on the ſame cauſe, that is, on its being a worſe conductor of heat than other metals; and hence the ſurface both acquires heat much ſooner, and loſes it much ſooner, than the internal parts of it, in this circumſtance reſembling glaſs.

When ſteel is made very hot, and ſuddenly immerged in very cold water, and moved about in it, the ſurface of the ſteel becomes cooled firſt, and thus producing a kind of caſe or arch over the internal part, prevents that internal part from contracting quite ſo much as it otherwiſe would do, whence it becomes brittler and harder, like the glaſs-drops called Prince Rupert's drops, which are made by dropping melted glaſs into cold water. This idea is countenanced by the circumſtance that hardened ſteel is ſpecifically lighter than ſteel which is more gradually cooled. (Nicholſon's Chemiſtry, p. 313.) Why the brittleneſs and hardneſs of ſteel or glaſs ſhould keep pace or be companions to each other may be difficult to conceive.

When a ſteel ſpring is forcibly bent till it break, it requires leſs power to bend it through the firſt inch than the ſecond, and leſs through the ſecond than the third; the ſame I ſuppoſe to happen if a wire be diſtended till it break by hanging weights to it; this ſhews that the particles may be forced from each other to a ſmall diſtance by leſs power, than is neceſſary to make them recede to a greater diſtance; in this circumſtance perhaps the attraction of coheſion differs from that of gravitation, which exerts its power inverſely as the ſquares of the diſtance. Hence it appears that if the innermoſt particles of a ſteel bar, by cooling the external ſurface firſt, are kept from approaching each other ſo nearly as they otherwiſe would do, that they become in the ſituation of the particles on the convex ſide of a bent ſpring, and can not be forced further from each other except by a greater power than would have been neceſſary to have made them recede thus far. And ſecondly, that if they be forced a little further from each other they ſeparate; this may be exemplified by laying two magnetic needles parallel to each other, the contrary poles together, then drawing them longitudinally from each other, they will ſlide with ſmall force till they begin to ſeparate, and will then require a ſtronger force to really ſeparate them. Hence it appears, that hardneſs and brittleneſs depend on the ſame circumſtance, that the particles are removed to a greater diſtance from each other and thus reſiſt any power more forcibly which is applied to diſplace them further, this conſtitutes hardneſs. And ſecondly, if they are diſplaced by ſuch applied force they immediately ſeparate, and this conſtitutes brittleneſs.

Steel may be thus rendered too brittle for many purpoſes, on which account artiſts have means of ſoftening it again, by expoſing it to certain degrees of heat, for the conſtruction of different kinds of tools, which is called tempering it. Some artiſts plunge large tools in very cold water as ſoon as they are compleatly ignited, and moving it about,

take it out as foon as it ceafes to be luminous beneath the water; it is then rubbed quickly with a file or on fand to clean the furface, the heat which the metal ftill retains foon begins to produce a fucceffion of colours; if a hard temper be required, the piece is dipped again and ftirred about in cold water as foon as the yellow tinge appears, if it be cooled when the purple tinge appears it becomes fit for gravers' tools ufed in working upon metals; if cooled while blue it is proper for fprings. Nicholfon's Chemiftry, p. 313. Keir's Chemical Dictionary.

MODERN PRODUCTION OF IRON.

The recent production of iron is evinced from the chalybeate waters which flow from moraffes which lie upon gravel-beds, and which muft therefore have produced iron after thofe gravel-beds were raifed out of the fea. On the fouth fide of the road between Cheadle and Okeymoor in Staffordfhire, yellow ftains of iron are feen to penetrate the gravel from a thin morafs on its furface. There is a fiffure eight or ten feet wide, in a gravel-bed on the eaftern fide of the hollow road afcending the hill about a mile from Trentham in Staffordfhire, leading toward Drayton in Shropfhire, which fiffure is filled up with nodules of iron-ore. A bank of fods is now raifed againft this fiffure to prevent the loofe iron nodules from falling into the turnpike road, and thus this natural curiofity is at prefent concealed from travellers. A fimilar fiffure in a bed of marl, and filled up with iron nodules and with fome large pieces of flint, is feen on the eaftern fide of the hollow road afcending the hill from the turnpike houfe about a mile from Derby in the road towards Burton. And another fuch fiffure filled with iron nodes, appears about half a mile from Newton-Solney in Derbyfhire, in the road to Burton, near the fummit of the hill. Thefe collections of iron and of flint muft have been produced pofterior to the elevation of all thofe hills, and were thence evidently of vegetable or animal origin. To which fhould be added, that iron is found in general in beds either near the furface of the earth, or ftratified with clay coals or argillaceous grit, which are themfelves productions of the modern world, that is, from the recrements of vegetables and air-breathing animals.

Not only iron but manganefe, calamy, and even copper and lead appear in fome inftances to have been of recent production. Iron and manganefe are detected in all vegetable productions, and it is probable other metallic bodies might be found to exift in vegetable or animal matters, if we had tefts to detect them in very minute quantities. Manganefe and calamy are found in beds like iron near the furface of the earth, and in a calciform ftate, which countenances their modern production. The recent production of calamy, one of the ores of zinc, appears from its frequently incrufting calcareous fpar in its defcent from the furface of the earth into the uppermoft fiffures of the limeftone mountains of Derbyfhire. That the calamy has been carried by its folution or diffufion in water into thefe cavities, and not by its afcent from below in form of fteam, is evinced from its not only forming a cruft over the dogtooth fpar, but by its afterwards diffolving or deftroying the fparry cryftal. I have fpecimens of calamy in the form of dogtooth fpar, two inches high, which are hollow, and ftand half an inch above the diminifhed

ſparry cryſtal on which they were formed, like a ſheath a great deal too big for it; this ſeems to ſhew, that this proceſs was carried on in water, otherwiſe after the calamy had incruſted its ſpar, and diſſolved its ſurface, ſo as to form a hollow cavern over it, it could not act further upon it except by the interpoſition of ſome medium. As theſe ſpars and calamy are formed in the fiſſures of mountains they muſt both have been formed after the elevation of thoſe mountains.

In reſpect to the recent production of copper, it was before obſerved in note on Canto II. l. 394, that the ſummit of the grit-ſtone mountain at Hawkſtone in Shropſhire, is tinged with copper, which from the appearance of the blue ſtains ſeems to have deſcended to the parts of the rock beneath. I have a calciform ore of copper conſiſting of the hollow cruſts of cubic cells, which has evidently been formed on cryſtals of fluor, which it has eroded in the ſame manner as the calamy erodes the calcareous cryſtals, from whence may be deduced in the ſame manner, the aqueous ſolution or diffuſion, as well as the recent production of this calciform ore of copper.

Lead in ſmall quantities is ſometimes found in the fiſſures of coal-beds, which fiſſures are previouſly covered with ſpar; and ſometimes in nodules of iron-ore. Of the former I have a ſpecimen from near Caulk in Derbyſhire, and of the latter from Colebrook Dale in Shropſhire. Though all theſe facts ſhew that ſome metallic bodies are formed from vegetable or animal recrements, as iron, and perhaps mangañeſe and calamy, all which are found near the ſurface of the earth; yet as the other metals are found only in fiſſures of rocks, which penetrate to unknown depths, they may be wholly or in part produced by aſcending ſteams from ſubterraneous fires, as mentioned in note on Canto II. l. 394.

SEPTARIA OF IRON-STONE.

Over ſome lime works at Walſall in Staffordſhire, I obſerved ſome years ago a ſtratum of iron earth about ſix inches thick, full of very large cavities; theſe cavities were evidently produced when the material paſſed from a ſemifluid ſtate into a ſolid one; as the frit of the potters, or a mixture of clay and water is liable to crack in drying; which is owing to the further contraction of the internal part, after the cruſt is become hard. Theſe hollows are liable to receive extraneous matter, as I believe gypſum, and ſometimes ſpar, and even lead; a curious ſpecimen of the laſt was preſented to me by Mr. Darby of Colebrook Dale, which contains in its cavity ſome ounces of lead-ore. But there are other ſeptaria of iron-ſtone which ſeem to have had a very different origin, their cavities having been formed in cooling or congealing from an ignited ſtate, as is ingeniouſly deduced by Dr. Hutton from their internal ſtructure. Edinb. Tranſact. Vol. I. p. 246. The volcanic origin of theſe curious ſeptaria appears to me to be further evinced from their form and the places where they are found. They conſiſt of oblate ſpheroids and are found in many parts of the earth totally detached from the beds in which they lie, as at Eaſt Lothian in Scotland. Two of theſe, which now lie before me, were found with many others immerſed in argillaceous ſhale or ſhiver, ſurrounded by broken limeſtone mountains at Bradbourn near Aſhbourn in Derbyſhire, and were preſented to

me by Mr. Buxton, a gentleman of that town. One of these is about fifteen inches in its equatorial diameter, and about six inches in its polar one, and contains beautiful star-like septaria incrusted and in part filled with calcareous spar. The other is about eight inches in its equatorial diameter, and about four inches in its polar diameter, and is quite solid, but shews on its internal surface marks of different colours, as if a beginning separation had taken place. Now as these septaria contain fifty per cent. of iron, according to Dr. Hutton, they would soften or melt into a semifluid globule by subterraneous fire by less heat than the limestone in their vicinity; and if they were ejected through a hole or fissure would gain a circular motion along with their progressive one by their greater friction or adhesion to one side of the hole. This whirling motion would produce the oblate spheroidical form which they possess, and which as far as I know can not in any other way be accounted for. They would then harden in the air as they rose into the colder parts of the atmosphere; and as they descended into so soft a material as shale or shiver, their forms would not be injured in their fall; and their presence in materials so different from themselves becomes accounted for.

About the tropics of the large septarium above mentioned, are circular eminent lines, such as might have been left if it had been coarsely turned in a lathe. These lines seem to consist of a fluid matter, which seems to have exsuded in circular zones, as their edges appear blunted or retracted; and the septarium seems to have split easier in such sections parallel to its equator. Now as the crust would first begin to cool and harden after its ejection in a semifluid state, and the equatorial diameter would become gradually enlarged as it rose in the air; the internal parts being softer would slide beneath the polar crust, which might crack and permit part of the semifluid to exsude, and it is probable the adhesion would thus become less in sections parallel to the equator. Which further confirms this idea of the production of these curious septaria. A new-cast cannon ball red-hot with its crust only solid, if it were shot into the air would propably burst in its passage; as it would consist of a more fluid material than these septaria; and thus by discharging a shower of liquid iron would produce more dreadful combustion, if used in war, than could be effected by a ball, which had been cooled and was heated again: since in the latter case the ball could not have its internal parts made hotter than the crust of it, without first loosing its form.

NOTE XIX.——FLINT.

Tranſmute to glittering flints her chalky lands,
Or ſink on Ocean's bed in countleſs ſands. CANTO II. l. 217.

1. SILICEOUS ROCKS.

THE great maſſes of ſiliceous ſand which lie in rocks upon the beds of limeſtone, or which are ſtratified with clay, coal, and iron-ore, are evidently produced in the decompoſition of vegetable or animal matters, as explained in the note on moraſſes. Hence the impreſſions of vegetable roots and even whole trees are often found in ſand-ſtone, as well as in coals and iron-ore. In theſe ſand-rocks both the ſiliceous acid and the calcareous baſe ſeem to be produced from the materials of the moraſs; for though the preſence of a ſiliceous acid and of a calcareous baſe have not yet been ſeparately exhibited from flints, yet from the analogy of flint to fluor, and gypſum, and marble, and from the converſion of the latter into flint, there can be little doubt of their exiſtence.

Theſe ſiliceous ſand-rocks are either held together by a ſiliceous cement, or have a greater or leſs portion of clay in them, which in ſome acts as a cement to the ſiliceous cryſtals, but in others is in ſuch great abundance that in burning them they become an imperfect porcelain and are then uſed to repair the roads, as at Cheſterfield in Derbyſhire; theſe are called argillaceous grit by Mr. Kirwan. In other places a calcareous matter cements the cryſtals together; and in other places the ſiliceous cryſtals lie in looſe ſtrata under the marl in the form of white ſand; as at Normington about a mile from Derby.

The loweſt beds of ſiliceous ſand-ſtone produced from moraſſes ſeem to obtain their acid from the moraſs, and their calcareous baſe from the limeſtone on which it reſts. Theſe beds poſſeſs a ſiliceous cement, and from their greater purity and hardneſs are uſed for courſe grinding-ſtones and ſcyth ſtones, and are ſituated on the edges of limeſtone countries, having loſt the other ſtrata of coals, or clay, or iron, which were originally produced above them. Such are the ſand-rocks incumbent on limeſtone near Matlock in Derbyſhire. As theſe ſiliceous ſand-rocks contain no marine productions ſcattered amongſt them, they appear to have been elevated, torn to pieces, and many fragments of them ſcattered over the adjacent country by exploſions, from fires within the moraſs from which they have been formed; and which diſſipated every thing inflammable above and beneath them, except ſome ſtains of iron, with which they are in ſome places ſpotted. If theſe ſand-rocks had been accumulated beneath the ſea, and elevated along with the beds of limeſtone on which they reſt, ſome veſtiges of marine ſhells either in their ſiliceous or calcareous ſtate muſt have been diſcerned amongſt them.

2. SILICEOUS TREES.

In many of theſe ſand-rocks are found the impreſſions of vegetable roots, which ſeem to have been the moſt unchangeable parts of the plant, as ſhells and ſhark's teeth are found in chalk-beds from their being the moſt unchangeable parts of the animal. In other inſtances the wood itſelf is penetrated, and whole trees converted into flint; ſpecimens of which I have by me, from near Coventry, and from a gravel-pit in Shropſhire near Child's Archal in the road to Drayton. Other poliſhed ſpecimens of vegetable flints abound in the cabinets of the curious, which evidently ſhew the concentric circles of woody fibres, and their interſtices filled with whiter ſiliceous matter, with the branching off of the knots when cut horizontally, and the parallel lines of wood when cut longitudinally, with uncommon beauty and variety. Of theſe I poſſeſs ſome beautiful ſpecimens, which were preſented to me by the Earl of Uxbridge.

The colours of theſe ſiliceous vegetables are generally brown, from the iron, I ſuppoſe, or mangan eſe, which induced them to cryſtallize or to fuſe more eaſily. Some of the cracks of the wood in drying are filled with white flint or calcedony, and others of them remain hollow, lined with innumerable ſmall cryſtals tinged with iron, which I ſuppoſe had a ſhare in converting their calcareous matter into ſiliceous cryſtals, becauſe the cryſtals called Peak-diamonds are always found bedded in an ochreous earth; and thoſe called Briſtol-ſtones are ſituated on limeſtone coloured with iron. Mr. F. French preſented me with a congeries of ſiliceous cryſtals, which he gathered on the crater (as he ſuppoſes) of an extinguiſhed volcano at Cromach Water in Cumberland. The cryſtals are about an inch high in the ſhape of dogtooth or calcareous ſpar, covered with a dark ferruginous matter. The bed on which they reſt is about an inch in thickneſs, and is ſtained with iron on its underſurface. This curious foſſil ſhews the tranſmutation of calcareous earth into ſiliceous, as much as the ſiliceous ſhells which abound in the cabinets of the curious. There may ſometime be diſcovered in this age of ſcience, a method of thus impregnating wood with liquid flint, which would produce pillars for the ſupport, and tiles for the covering of houſes, which would be uninflammable and endure as long as the earth beneath them.

That ſome ſiliceous productions have been in a fluid ſtate without much heat at the time of their formation appears from the vegetable flints above deſcribed not having quite loſt their organized appearance; from ſhells, and coralloids, and entrochi being converted into flint without looſing their form; from the baſon of calcedony round Gieſar in Iceland; and from the experiment of Mr. Bergman, who obtained thirteen regular formed cryſtals by ſuffering the powder of quartz to remain in a veſſel with fluor acid for two years; theſe cryſtals were about the ſize of ſmall peas, and were not ſo hard as quartz. Opuſc. de Terrâ Siliceâ, p. 33. Mr. Achard procured both calcareous and ſiliceous cryſtals, one from calcareous earth, and the other from the earth of alum, both diſſolved in water impregnated with fixed air; the water filtrating very ſlowly through a porous bottom of baked clay. See Journal de Phyſique, for January, 1778.

3. AGATES, ONYXES, SCOTS-PEBBLES.

In ſmall cavities of theſe ſand-rocks, I am informed, the beautiful ſiliceous nodules are found which are called Scot's-pebbles; and which on being cut in different directions take the names of agates, onyxes, ſardonyxes, &c. according to the colours of the lines or ſtrata which they exhibit. Some of the nodules are hollow and filled with cryſtals, others have a nucleus of leſs compact ſiliceous matter which is generally white, ſurrounded with many concentric ſtrata coloured with iron, and other alternate ſtrata of white agate or calcedony, ſometimes to the number of thirty.

I think theſe nodules bear evident marks of their having been in perfect fuſion by either heat alone, or by water and heat, under great preſſure, according to the ingenious theory of Dr. Hutton; but I do not imagine, that they were injected into cavities from materials from without, but that ſome vegetables or parts of vegetables containing more iron or mangancſe than others, facilitated the compleat fuſion, thus deſtroying the veſtiges of vegetable organization, which were conſpicuous in the ſiliceous trees above mentioned. Some of theſe nodules being hollow and lined with cryſtals, and others containing a nucleus of white ſiliceous matter of a looſer texture, ſhew they were compoſed of the materials then exiſting in the cavity; which conſiſting before of looſe ſand, muſt take up leſs ſpace when fuſed into a ſolid maſs.

Theſe ſiliceous nodules reſemble the nodules of iron-ſtone mentioned in note on Canto II. l. 179, in reſpect to their poſſeſſing a great number of concentric ſpheres coloured generally with iron, but they differ in this circumſtance, that the concentric ſpheres generally obey the form of the external cruſt, and in their not poſſeſſing a chalybeate nucleus. The ſtalactites formed on the roofs of caverns are often coloured in concentric ſtrata, by their coats being ſpread over each other at different times; and ſome of them, as the cupreous ones, poſſeſs great beauty from this formation; but as theſe are neceſſarily more or leſs of a cylindrical or conic form, the nodules or globular flints above deſcribed cannot have been conſtructed in this manner. To what law of nature then is to be referred the production of ſuch numerous concentric ſpheres? I ſuſpect to the law of congelation.

When ſalt and water are expoſed to ſevere froſty air, the ſalt is ſaid to be precipitated as the water freezes; that is, as the heat, in which it was diſſolved, is withdrawn; where the experiment is tried in a bowl or baſon, this may be true, as the ſurface freezes firſt, and the ſalt is found at the bottom. But in a fluid expoſed in a thin phial, I found by experiment, that the extraneous matter previouſly diſſolved by the heat in the mixture was not ſimply ſet at liberty to ſubſide, but was detruded or puſhed backward as the ice was produced. The experiment was this: about two ounces of a ſolution of blue vitriol were accidentally frozen in a thin phial, the glaſs was cracked and fallen to pieces, the ice was diſſolved, and I found a pillar of blue vitriol ſtanding erect on the bottom of the broken bottle. Nor is this power of congelation more extraordinary, than that by its powerful and ſudden expanſion it ſhould burſt iron ſhells and coehorns, or throw

out the plugs with which the water was secured in them above one hundred and thirty yards, according to the experiments at Quebec by Major Williams. Edinb. Transact. Vol. II. p. 23.

In some siliceous nodules which now lie before me, the external crust for about the tenth of an inch consists of white agate, in others it is much thinner, and in some much thicker, corresponding with this crust there are from twenty to thirty superincumbent strata, of alternately darker and lighter colour; whence it appears, that the external crust as it cooled or froze, propelled from it the iron or manganese which was dissolved in it; this receded till it had formed an arch or vault strong enough to resist its further protrusion; then the next inner sphere or stratum as it cooled or froze, propelled forwards its colouring matter in the same manner, till another arch or sphere produced sufficient resistance to this frigorific expulsion. Some of them have detruded their colouring matter quite to the centre, the rings continuing to become darker as they are nearer it; in others the chalybeate arch seems to have stopped half an inch from the centre, and become thicker by having attracted to itself the irony matter from the white nucleus, owing probably to its cooling less precipitately in the central parts than at the surface of the pebble.

A similar detrusion of a marly matter in circular arches or vaults obtains in the salt mines in Cheshire; from whence Dr. Hutton very ingeniously concludes, that the salt must have been liquified by heat; which would seem to be be much confirmed by the above theory. Edinb. Transact. Vol. I. p. 244.

I cannot conclude this account of Scots-pebbles without observing that some of them on being sawed longitudinally asunder, seem still to possess some vestiges of the cylindrical organization of vegetables; others possess a nucleus of white agate much resembling some bulbous roots with their concentric coats, or the knots in elm-roots or crab-trees, some of these I suppose were formed in the manner above explained, during the congelation of masses of melted flint and iron; others may have been formed from a vegetable nucleus, and retain some vestiges of the organization of the plant.

4. SAND OF THE SEA.

The great abundance of siliceous sand at the bottom of the ocean may in part be washed down from the siliceous rocks above described, but in general I suppose it derives its acid only from the vegetable and animal matter of morasses, which is carried down by floods or by the atmosphere, and becomes united in the sea with its calcareous base from shells and coralloids, and thus assumes its crystalline form at the bottom of the ocean, and is then intermixed with gravel or other matters washed from the mountains in its vicinity.

5. CHERT, OR PETROSILEX.

The rocks of marble are often alternately intermixed with strata of chert, or coarse flint, and this in beds from one to three feet thick, as at Ilam and Matlock, or of less than the tenth of an inch in thickness, as a mile or two from Bakewell in the road to

Buxton. It is difficult to conceive in what manner ten or twenty ſtrata of either limeſtone or flint, of different ſhades of white and black, could be laid quite regularly over each other from ſediments or precipitations from the ſea; it appears to me much eaſier to comprehend, by ſuppoſing with Dr. Hutton, that both the ſolid rocks of marble and the flint had been fuſed by great heat, (or by heat and water,) under immenſe preſſure; by its cooling or congelating the colouring matter might be detruded, and form parallel or curvilinean ſtrata, as above explained.

The colouring matter both of limeſtone and flint was probably owing to the fleſh of peculiar animals, as well as the ſiliceous acid, which converted ſome of the limeſtone into flint; or to ſome ſtrata of ſhell-fiſh having been overwhelmed when alive with new materials, while others dying in their natural ſituations would loſe their fleſhy parts, either by its putrid ſolution in the water or by its being eaten by other ſea-inſects. I have ſome calcareous foſſil ſhells which contain a black coaly matter in them, which was evidently the body of the animal, and others of the ſame kind filled with ſpar inſtead of it. The Labradore ſtone has I ſuppoſe its colours from the nacre or mother-pearl ſhells, from which it was probably produced. And there is a ſtratum of calcareous matter about ſix or eight inches thick at Wingerworth in Derbyſhire over the iron-beds, which is replete with ſhells of freſh-water muſcles, and evidently obtains its dark colour from them, as mentioned in note XVI. Many nodules of flint reſemble in colour as well as in form the ſhell of the echinus or ſea-urchin; others reſemble ſome coralloids both in form and colour; and M. Arduini found in the Monte de Pancraſio, red flints branching like corals, from whence they ſeem to have obtained both their form and their colour. Ferber's Travels in Italy, p. 42.

6. NODULES OF FLINT IN CHALK-BEDS.

As the nodules of flint found in chalk-beds poſſeſs no marks of having been rounded by attrition or ſolution, I conclude that they have gained their form as well as their dark colour from the fleſh of the ſhell-fiſh from which they had their origin; but which have been ſo compleatly fuſed by heat, or heat and water, as to obliterate all veſtiges of the ſhell, in the ſame manner as the nodules of agate and onyx were produced from parts of vegetables, but which had been ſo completely fuſed as to obliterate all marks of their organization, or as many iron-nodules have obtained their form and origin from peculiar vegetables.

Some nodules in chalk-beds conſiſt of ſhells of echini filled up with chalk, the animal having been diſſolved away by putreſcence in water, or eaten by other ſea-inſects; other ſhells of echini, in which I ſuppoſe the animal's body remained, are converted into flint, but ſtill retain the form of the ſhell. Others, I ſuppoſe as above, being more completely fuſed, have become flint coloured by the animal fleſh, but without the exact form either of the fleſh or ſhell of the animal. Many of theſe are hollow within and lined with cryſtals, like the Scot's-pebbles above deſcribed; but as the colouring matter of animal

bodies differs but little from each other compared with those of vegetables, these flints vary less in their colours than those above mentioned. At the same time as they cooled in concentric spheres like the Scot's-pebbles, they often possess faint rings of colours, and always break in concholoid forms like them.

This idea of the production of nodules of flint in chalk-beds is countenanced from the iron which generally appears as these flints become decomposed by the air; which by uniting with the iron in their composition reduces it from a vitrescent state to that of calx, and thus renders it visible. And secondly, by there being no appearance in chalk-beds of a string or pipe of siliceous matter connecting one nodule with another, which must have happened if the siliceous matter, or its acid, had been injected from without according to the idea of Dr. Hutton. And thirdly, because many of them have very large cavities at their centres, which should not have happened had they been formed by the injection of a material from without.

When shells or chalk are thus converted from calcareous to siliceous matter by the flesh of the animal, the new flint being heavier than the shell or chalk occupies less space than the materials it was produced from; this is the cause of frequent cavities within them, where the whole mass has not been completely fused and pressed together. In Derbyshire there are masses of coralloid and other shells which have become siliceous, and are thus left with large vacuities sometimes within and sometimes on the outside of the remaining form of the shell, like the French millstones, and I suppose might serve the same purpose; the gravel of the Derwent is full of specimens of this kind.

Since writing the above I have received a very ingenious account of chalk-beds from Dr. MENISH of Chelmsford. He distinguishes chalk-beds into three kinds; such as have been raised from the sea with little disturbance of their strata, as the cliffs of Dover and Margate, which he terms *intire* chalk. Another state of chalk is where it has suffered much derangement, as the banks of the Thames at Gravesend and Dartford. And a third state where fragments of chalk have been rounded by water, which he terms *alluvial* chalk. In the first of these situations of chalk he observes, that the flint lies in strata horizontally, generally in distinct nodules, but that he has observed two instances of solid plates or strata of flint, from an inch to two inches in thickness, interposed between the chalk-beds; one of these is in a chalk-bank by the road side at Berkhamstead, the other in a bank on the road from Chatham leading to Canterbury. Dr. Menish has further observed, that many of the echini are crushed in their form, and yet filled with flint, which has taken the form of the crushed shell, and that though many flint nodules are hollow, yet that in some echini the siliceum seems to have enlarged, as it passed from a fluid to a solid state, as it swells out in a protuberance at the mouth and anus of the shell, and that though these shells are so filled with flint yet that in many places the shell itself remains calcareous. These strata of nodules and plates of flint seem to countenance their origin from the flesh of a stratum of animals which perished by some natural violence, and were buried in their shells.

7. ANGLES OF SILICEOUS SAND.

In many rocks of ſiliceous ſand the particles retain their angular form, and in ſome beds of looſe ſand, of which there is one of conſiderable purity a few yards beneath the marl at Normington about a mile ſouth of Derby. Other ſiliceous ſands have had their angles rounded off, like the pebbles in gravel-beds. Theſe ſeem to owe their globular form to two cauſes; one to their attrition againſt each other, when they may for centuries have lain at the bottom of the ſea, or of rivers; where they may have been progreſſively accumulated, and thus progreſſively at the ſame time rubbed upon each other by the daſhing of the water, and where they would be more eaſily rolled over each other by their gravity being ſo much leſs than in air. This is evidently now going on in the river Derwent, for though there are no limeſtone rocks for ten or fifteen miles above Derby, yet a great part of the river-gravel at Derby conſiſts of limeſtone nodules, whoſe angles are quite worn off in their deſcent down the ſtream.

There is however another cauſe which muſt have contributed to round the angles both of calcareous and ſiliceous fragments; and that is, their ſolubility in water; calcareous earth is perpetually found ſuſpended in the waters which paſs over it; and the earth of flints was obſerved by Bergman to be contained in water in the proportion of one grain to a gallon. Kirwan's Mineralogy, p. 107. In boiling water, however, it is ſoluble in much greater proportion, as appears from the ſiliceous earth ſublimed in the diſtillation of fluor acid in glaſs veſſels; and from the baſons of calcedony which ſurrounded the jets of hot water near mount Heccla in Iceland. Troil on Iceland. It is probable moſt ſiliceous ſands or pebbles have at ſome ages of the world been long expoſed to aqueous ſteams raiſed by ſubterranean fires. And if fragments of ſtone were long immerſed in a fluid menſtrum, their angular parts would be firſt diſſolved, on account of their greater ſurface.

Many beds of ſiliceous gravel are cemented together by a ſiliceous cement, and are called breccia; as the plumb-pudding ſtones of Hartfordſhire, and the walls of a ſubterraneous temple excavated by Mr. Curzon, at Hagley near Rugely in Staffordſhire; theſe may have been expoſed to great heat as they were immerſed in water; which water under great preſſure of ſuperincumbent materials may have been rendered red-hot, as in Papin's digeſter; and have thus poſſeſſed powers of ſolution with which we are unacquainted.

8. BASALTES AND GRANITES.

Another ſourſe of ſiliceous ſtones is from the granite, or baſaltes, or porphyrics, which are of different hardneſſes according to the materials of their compoſition, or to the fire they have undergone; ſuch are the ſtones of Arthur's-hill near Edinburgh, of the Giant's Cauſway in Ireland, and of Charnwood Foreſt in Leiceſterſhire; the uppermoſt ſtratum of which laſt ſeems to have been cracked either by its elevation, or by its haſtily cooling after ignition by the contact of dews or ſnows, and thus breaks into angular fragments, ſuch as the ſtreets of London are paved with; or have had their angles rounded by

attrition or by partial ſolution; and have thus formed the common paving ſtones or bowlers; as well as the gravel, which is often rolled into ſtrata amid the ſiliceous ſand-beds, which are either formed or collected in the ſea.

In what manner ſuch a maſs of cryſtallized matter as the Giant's Cauſway and ſimilar columns of baſaltes, could have been raiſed without other volcanic appearances, may be a matter not eaſy to comprehend; but there is another power in nature beſides that of expanſile vapour which may have raiſed ſome materials which have previouſly been in igneous or aqueous ſolution; and that is the act of congelation. When the water in the experiments above related of Major Williams had by congelation thrown out the plugs from the bomb-ſhells, a column of ice roſe from the hole of the bomb ſix or eight inches high. Other bodies I ſuſpect increaſe in bulk which cryſtallize in cooling, as iron and type-metal. I remember pouring eight or ten pounds of melted brimſtone into a pot to cool and was ſurprized to ſee after a little time a part of the fluid beneath break a hole in the congealed cruſt above it, and gradually riſe into a promontory ſeveral inches high; the baſaltes has many marks of fuſion and of cryſtallization and may thence, as well as many other kinds of rocks, as of ſpar, marble, petroſilex, jaſper, &c. have been raiſed by the power of congelation, a power whoſe quantity has not yet been aſcertained, and perhaps greater and more univerſal than that of vapours expanded by heat. Theſe baſaltic columns riſe ſometimes out of mountains of granite itſelf, as mentioned by Dr. Beddoes, (Phil. Tranſact. Vol. LXXX.) and as they ſeem to conſiſt of ſimilar materials more completely fuſed, there is ſtill greater reaſon to believe them to have been elevated in the cooling or cryſtallization of the maſs. See note XXIV.

NOTE XX.——CLAY.

Whence ductile Clays in wide expansion spread,
Soft as the Cygnet's down, their snow-white bed. CANTO II. l. 276.

THE philosophers, who have attended to the formation of the earth, have acknowledged two great agents in producing the various changes which the terraqueous globe has undergone, and these are water and fire. Some of them have perhaps ascribed too much to one of these great agents of nature, and some to the other. They have generally agreed that the stratification of materials could only be produced from sediments or precipitations, which were previously mixed or dissolved in the sea; and that whatever effects were produced by fire were performed afterwards.

There is however great difficulty in accounting for the universal stratification of the solid globe of the earth in this manner, since many of the materials, which appear in strata, could not have been suspended in water; as the nodules of flint in chalk-beds, the extensive beds of shells, and lastly the strata of coal, clay, sand, and iron-ore, which in most coal-countries lie from five to seven times alternately stratified over each other, and none of them are soluble in water. Add to this if a solution of them or a mixture of them in water could be supposed, the cause of that solution must cease before a precipitation could commence.

1. The great masses of lava, under the various names of granite, porphyry, toadstone, moor-stone, rag, and slate, which constitute the old word, may have acquired the stratification, which some of them appear to possess, by their having been formed by successive eruptions of a fluid mass, which at different periods of antient time arose from volcanic shafts and covered each other, the surface of the interior mass of lava would cool and become solid before the superincumbent stratum was poured over it; to the same cause may be ascribed their different compositions and textures, which are scarcely the same in any two parts of the world.

2. The stratifications of the great masses of limestone, which were produced from sea-shells, seem to have been formed by the different times at which the innumerable shells were produced and deposited. A colony of echini, or madrepores, or cornua ammonis, lived and perished in one period of time; in another a new colony of either similar or different shells lived and died over the former ones, producing a stratum of more recent shell over a stratum of others which had began to petrify or to become marble; and thus from unknown depths to what are now the summits of mountains the limestone is disposed in strata of varying solidity and colour. These have afterwards undergone variety of changes by their solution and deposition from the water in which they were immersed, or from having been exposed to great heat under great pressure, according to the ingenious theory of Dr. Hutton. Edinb. Transact. Vol. I. See Note XVI.

3. In moſt of the coal-countries of this iſland there are from five to ſeven beds of coal ſtratified with an equal number of beds, though of much greater thickneſs, of clay and ſandſtone, and occaſionally of iron-ores. In what manner to account for the ſtratification of theſe materials ſeems to be a problem of greater difficulty. Philoſophers have generally ſuppoſed that they have been arranged by the currents of the ſea; but conſidering their inſolubility in water, and their almoſt ſimilar ſpecific gravity, an accumulation of them in ſuch diſtinct beds from this cauſe is altogether inconceiveable, though ſome coal-countries bear marks of having been at ſome time immerſed beneath the waves and raiſed again by ſubterranean fires.

The higher and lower parts of moraſſes were neceſſarily produced at different periods of time, ſee Note XVII. and would thus originally be formed in ſtrata of different ages. For when an old wood periſhed, and produced a moraſs, many centuries would elapſe before another wood could grow and periſh again upon the ſame ground, which would thus produce a new ſtratum of moraſs over the other, differing indeed principally in its age, and perhaps, as the timber might be different, in the proportions of its component parts.

Now if we ſuppoſe the lowermoſt ſtratum of a moraſs become ignited, like fermenting hay, (after whatever could be carried away by ſolution in water was gone,) what would happen? Certainly the inflammable part, the oil, ſulphur, or bitumen, would burn away, and be evaporated in air; and the fixed parts would be left, as clay, lime, and iron; while ſome of the calcareous earth would join with the ſiliceous acid, and produce ſand, or with the argillaceous earth, and produce marl. Thence after many centuries another bed would take fire, but with leſs degree of ignition, and with a greater body of moraſs over it, what then would happen? The bitumen and ſulphur would riſe and might become condenſed under an impervious ſtratum, which might not be ignited, and there form coal of different purities according to its degree of fluidity, which would permit ſome of the clay to ſubſide through it into the place from which it was ſublimed.

Some centuries afterwards another ſimilar proceſs might take place, and either thicken the coal-bed, or produce a new clay-bed, or marl, or ſand, or depoſit iron upon it, according to the concomitant circumſtances above mentioned.

I do not mean to contend that a few maſſes of ſome materials may not have been rolled together by currents, when the mountains were much more elevated than at preſent, and in conſequence the rivers broader and more rapid, and the ſtorms of rain and wind greater both in quantity and force. Some gravel-beds may have been thus waſhed from the mountains; and ſome white clay waſhed from moraſſes into valleys beneath them; and ſome ochres of iron diſſolved and again depoſited by water; and ſome calcareous depoſitions from water, (as the bank for inſtance on which ſtand the houſes at Matlock-bath;) but theſe are of ſmall extent or conſequence compared to the primitive rocks of granite or porpyhry which form the nucleus of the earth, or to the immenſe ſtrata of limeſtone which cruſt over the greateſt part of this granite or porphyry; or laſtly to the very extenſive beds of clay, marl, ſandſtone, coal, and iron,

which were probably for many millions of years the only parts of our continents and iſlands, which were then elevated above the level of the ſea, and which on that account became covered with vegetation, and thence acquired their later or ſuperincumbent ſtrata, which conſtitute, what ſome have termed, the new world.

There is another ſource of clay, and that of the fineſt kind, from decompoſed granite, this is of a ſnowy white and mixed with ſhining particles of mica, of this kind is an earth from the country of Cherokees. Other kinds are from leſs pure lavas; Mr. Ferber aſſerts that the ſulphurous ſteams from Mount Veſuvius convert the lava into clay.

"The lavas of the antient Solfatara volcano have been undoubtedly of a vitreous nature, and theſe appear at preſent argillaceous. Some fragments of this lava are but half or at one ſide changed into clay, which either is viſcid or ductile, or hard and ſtoney. Clays by fire are deprived of their coherent quality, which cannot be reſtored to them by pulverization, nor by humectation. But the ſulphureous Solfatara ſteams reſtore it, as may be eaſily obſerved on the broken pots wherein they gather the ſal ammoniac; though very well baked and burnt at Naples they are mollified again by the acid ſteams into a viſcid clay which keeps the former fire-burnt colour." Travels in Italy, p. 156.

NOTE XXI.—ENAMELS.

Smear'd her huge dragons with metallic hues,
With golden purples, and cobaltic blues; CANTO II. l. 287.

THE fine bright purples or roſe colours which we ſee on china cups are not producible with any other material except gold, manganeſe indeed gives a purple but of a very different kind.

In Europe the application of gold to theſe purpoſes appears to be of modern invention. Caſſius's diſcovery of the precipitate of gold by tin, and the uſe of that precipitate for colouring glaſs and enamels, are now generally known, but though the precipitate with tin be more ſucceſsful in producing the ruby glaſs, or the colourleſs glaſs which becomes red by ſubſequent ignition, the tin probably contributing to prevent the gold from ſeparating, (which it is very liable to do during the fuſion; yet, for enamels, the precipitates made by alcaline ſalts anſwer equally well, and give a finer red, the colour produced by the tin precipitate being a bluiſh purple, but with the others a roſe red. I am informed that ſome of our beſt artiſts prefer aurum fulminans, mixing it, before it has become dry, with the white compoſition or enamel flux; when once it is divided by the other matter, it is ground with great ſafety, and without the leaſt danger of exploſion, whether moiſt or dry. The colour is remarkably improved and brought forth by long grinding, which accordingly makes an eſſential circumſtance in the proceſs.

The precipitates of gold, and the colcothar or other red preparations of iron, are called *tender* colours. The heat must be no greater than is just sufficient to make the enamel run upon the piece, for if greater, the colours will be destroyed or changed to a different kind. When the vitreous matter has just become fluid it seems as if the coloured metallic calx remained barely *intermixed* with it, like a coloured powder of exquisite tenuity suspended in water: but by stronger fire the calx is *dissolved*, and metallic colours are altered by *solution* in glass as well as in acids or alcalies.

The Saxon mines have till very lately almost exclusively supplied the rest of Europe with cobalt, or rather with its preparations, zaffre and smalt, for the exportation of the ore itself is there a capital crime. Hungary, Spain, Sweden, and some other parts of the continent, are now said to afford cobalts equal to the Saxon, and specimens have been discovered in our own island, both in Cornwall and in Scotland, but hitherto in no great quantity.

Calces of cobalt and of copper differ very materially from those above mentioned in their application for colouring enamels. In those the calx has previously acquired the intended colour, a colour which bears a red heat without injury, and all that remains is to fix it on the piece by a vitreous flux. But the blue colour of cobalt, and the green or bluish green of copper, are *produced* by vitrification, that is, by *solution* in the glass, and a strong fire is necessary for their perfection. These calces therefore, when mixed with the enamel flux, are melted in crucibles, once or oftener, and the deep coloured opake glass, thence resulting, is ground into unpalpable powder, and used for enamel. One part of either of these calces is put to ten, sixteen, or twenty parts of the flux, according to the depth of colour required. The heat of the enamel kiln is only a full red, such as is marked on Mr. Wedgwood's thermometer 6 degrees. It is therefore necessary that the flux be so adjusted as to melt in that low heat. The usual materials are flint, or flint glass, with a due proportion of red-led, or borax, or both and sometimes a little tin calx to give opacity.

Ka-o-lin is the name given by the Chinese to their porcelain clay, and *pe-tun-tse* to the other ingredient in their China ware. Specimens of both these have been brought into England, and found to agree in quality with some of our own materials. Kaolin is the very same with the clay called in Cornwall and the petuntse is a granite similar to the Cornish moorstone. There are differences both in the Chinese petuntses, and the English moorstones; all of them contain micaceous and quartzy particles, in greater or less quantity, along with feltspat, which last is the essential ingredient for the porcelain manufactory. The only injurious material commonly found in them is iron, which discolours the ware in proportion to its quantity, and which our moorstones are perhaps more frequently tainted with than the Chinese. Very fine porcelain has been made from English materials but the nature of the manufacture renders the process precarious and the profit hazardous; for the semivitrification, which constitutes porcelain, is necessarily accompanied with a degree of softness, or semifusion, so that the vessels are liable to have their forms altered in the kiln, or to run together with any accidental augmentations of the fire.



NOTE XXII.——PORTLAND VASE.

Or bid Mortality rejoice or mourn
O'er the fine forms of Portland's mystic urn. CANTO II. l. 321.

THE celebrated funereal vase, long in possession of the Barberini family, and lately purchased by the Duke of Portland for a thousand guineas, is about ten inches high and six in diameter in the broadest part. The figures are of most exquisite workmanship in bas relief of white opake glass, raised on a ground of deep blue glass, which appears black except when held against the light. Mr. Wedgwood is of opinion from many circumstances that the figures have been made by cutting away the external crust of white opake glass, in the manner the finest cameo's have been produced, and that it must thence have been the labour of a great many years. Some antiquarians have placed the time of its production many centuries before the christian æra; as sculpture was said to have been declining in respect to its excellence in the time of Alexander the Great. See an account of the Barberini or Portland vase by M. D'Hancarville, and by Mr. Wedgwood.

Many opinions and conjectures have been published concerning the figures on this celebrated vase. Having carefully examined one of Mr. Wedgwood's beautiful copies of this wonderful production of art, I shall add one more conjecture to the number.

Mr. Wedgwood has well observed that it does not seem probable that the Portland vase was purposely made for the ashes of any particular person deceased, because many years must have been necessary for its production. Hence it may be concluded, that the subject of its embellishments is not private history but of a general nature. This subject appears to me to be well chosen, and the story to be finely told; and that it represents what in antient times engaged the attention of philosophers, poets, and heroes, I mean a part of the Eleusinian mysteries.

These mysteries were invented in Ægypt, and afterwards transferred to Greece, and flourished more particularly at Athens, which was at the same time the seat of the fine arts. They consisted of scenical exhibitions representing and inculcating the expectation of a future life after death, and on this account were encouraged by the government, insomuch that the Athenian laws punished a discovery of their secrets with death. Dr. Warburton has with great learning and ingenuity shewn that the descent of Æneas into hell, described in the Sixth Book of Virgil, is a poetical account of the representations of the future state in the Eleusinian mysteries. Divine Legation, Vol. I. p. 210.

And though some writers have differed in opinion from Dr. Warburton on this subject, because Virgil has introduced some of his own heroes into the Elysian fields, as Deiphobus, Palinurus, and Dido, in the same manner as Homer had done before him, yet it is agreed that the received notions about a future state were exhibited in these mysteries, and as these poets described those received notions, they may be said, as far as these religious doctrines were concerned, to have described the mysteries.

Now as these were emblematic exhibitions they must have been as well adapted to the purposes of sculpture as of poetry, which indeed does not seem to have been uncommon, since one compartment of figures in the sheild of Æneas represented the regions of Tartarus. Æn. Lib. X. The procession of torches, which according to M. De St. Croix was exhibited in these mysteries, is still to be seen in basso relievo, discovered by Spon and Wheler. Memoires sur le Mysteres par De St. Croix. 1784. And it is very probable that the beautiful gem representing the marriage of Cupid and Psyche, as described by Apuleus, was originally descriptive of another part of the exhibitions in these mysteries, though afterwards it became a common subject of antient art. See Divine Legat. Vol. I. p. 323. What subject could have been imagined so sublime for the ornaments of a funereal urn as the mortality of all things and their resuscitation? Where could the designer be supplied with emblems for this purpose, before the Christian æra, but from the Eleusinian mysteries?

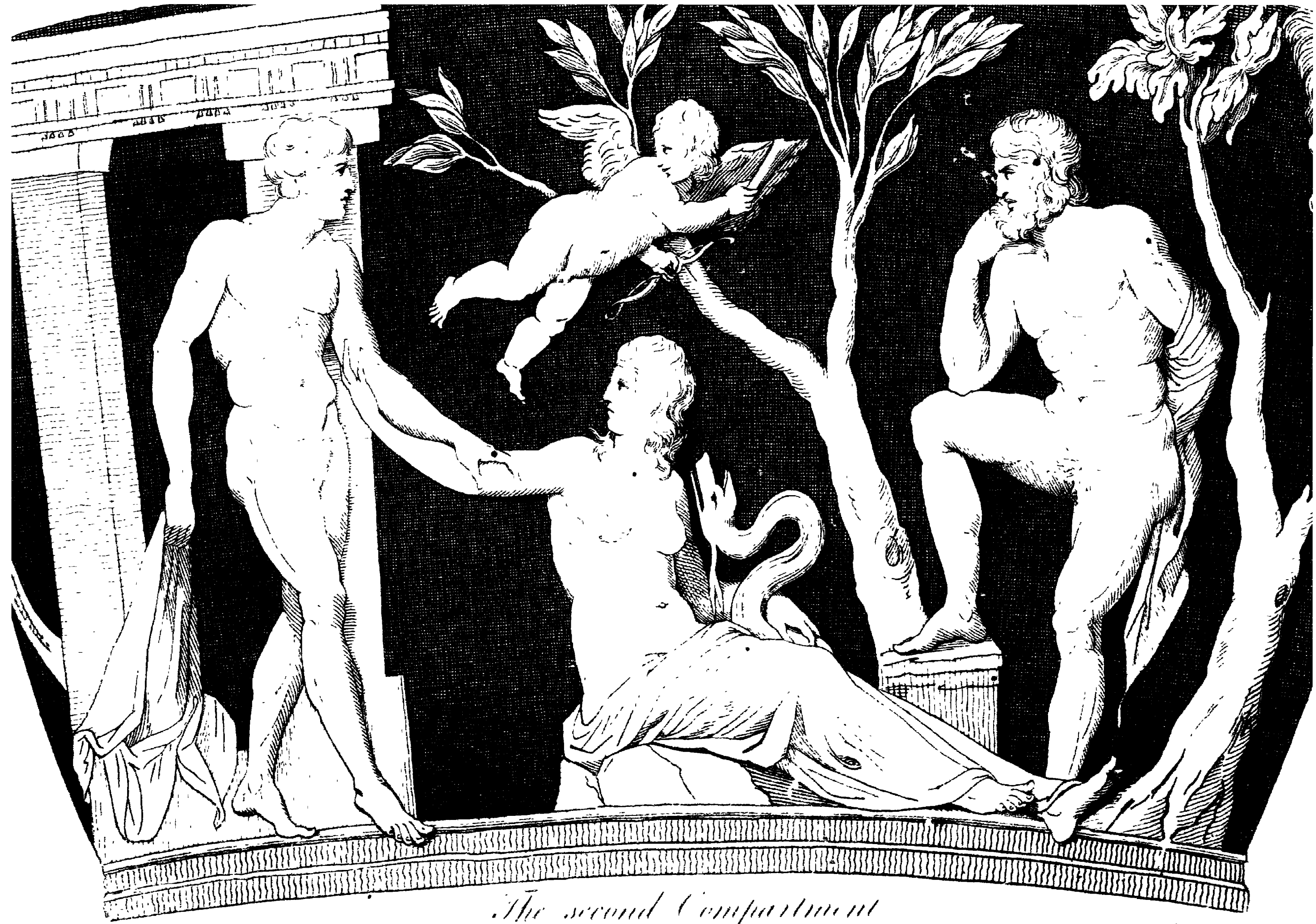
I. The exhibitions of the mysteries were of two kinds, those which the people were permitted to see, and those which were only shewn to the initiated. Concerning the latter, Aristides calls them "the most shocking and most ravishing representations." And Stobœus asserts that the initiation into the grand mysteries exactly resembles death. Divine Legat. Vol. I. p. 280, and p. 272. And Virgil in his entrance to the shades below, amongst other things of terrible form, mentions death Æn. VI. This part of the exhibition seems to be represented in one of the compartments of the Portland vase.

Three figures of exquisite workmanship are placed by the side of a ruined column whose capital is fallen off, and lies at their feet with other disjointed stones, they sit on loose piles of stone beneath a tree, which has not the leaves of any evergreen of this climate, but may be supposed to be an elm, which Virgil places near the entrance of the infernal regions, and adds, that a dream was believed to dwell under every leaf of it. Æn. VI. l. 281. In the midst of this group reclines a female figure in a dying attitude, in which extreme languor is beautifully represented, in her hand is an inverted torch, an antient emblem of extinguished life, the elbow of the same arm resting on a stone supports her as she sinks, while the other hand is raised and thrown over her drooping head, in some measure sustaining it and gives with great art the idea of fainting lassitude. On the right of her sits a man, and on the left a woman, both supporting themselves on their arms, as people are liable to do when they are thinking intensely. They have their backs towards the dying figure, yet with their faces turned towards her, as if seriously contemplating her situation, but without stretching out their hands to assist her.

This central figure then appears to me to be an hieroglyphic or Eleusinian emblem of MORTAL LIFE, that is, the lethum, or death, mentioned by Virgil amongst the terrible things exhibited at the beginning of the mysteries. The inverted torch shews the figure to be emblematic, if it had been designed to represent a real person in the act of dying there had been no necessity for the expiring torch, as the dying figure alone would have been sufficiently intelligible;—it would have been as absurd, as to have put an inverted torch into the hand of a real person at the time of his expiring. Besides if this



The first Compartment



The second Compartment

figure had reprefented a real dying perfon would not the other figures, or one of them at leaft, have ftretched out a hand to fupport her, to have eafed her fall among loofe ftones, or to have fmoothed her pillow? Thefe circumftances evince that the figure is an emblem, and therefore could not be a reprefentation of the private hiftory of any particular family or event.

The man and woman on each fide of the dying figure muft be confidered as emblems, both from their fimilarity of fituation and drefs to the middle figure, and their being grouped along with it. Thefe I think are hieroglyphic or Eleufinian emblems of HUMANKIND, with their backs toward the dying figure of MORTAL LIFE, unwilling to affociate with her, yet turning back their ferious and attentive countenances, curious indeed to behold, yet forry to contemplate their latter end. Thefe figures bring ftrongly to one's mind the Adam and Eve of facred writ, whom fome have fuppofed to have been allegorical or hieroglyphic perfons of Ægyptian origin, but of more antient date, amongft whom I think is Dr. Warburton. According to this opinion Adam and Eve were the names of two hieroglyphic figures reprefenting the early ftate of mankind; Abel was the name of an hieroglyphic figure reprefenting the age of pafturage, and Cain the name of another hieroglyphic fymbol reprefenting the age of agriculture, at which time the ufes of iron were difcovered. And as the people who cultivated the earth and built houfes would increafe in numbers much fafter by their greater production of food, they would readily conquer or deftroy the people who were fuftained by pafturage, which was typified by Cain flaying Abel.

2. On the other compartment of this celebrated vafe is exhibited an emblem of immortality, the reprefentation of which was well known to conftitute a very principal part of the fhews at the Eleufinian myfteries, as Dr. Warburton has proved by variety of authority. The habitation of fpirits or ghofts after death was fuppofed by the antients to be placed beneath the earth, where Pluto reigned, and difpenfed rewards or punifhments. Hence the firft figure in this group is of the MANES OR GHOST, who having paffed through an open portal is defcending into a dufky region, pointing his toe with timid and unfteady ftep, feeling as it were his way in the gloom. This portal Æneas enters, which is defcribed by Virgil,—patet atri janua ditis, Æn. VI. l. 126; as well as the eafy defcent,—facilis defcenfus Averni. Ib. The darknefs at the entrance to the fhades is humoroufly defcribed by Lucian. Div. Legat. Vol. I. p. 241. And the horror of the gates of hell was in the time of Homer become a proverb; Achilles fays to Ulyffes, "I hate a liar worfe than the gates of hell;" the fame expreffion is ufed in Ifaiah, ch. xxxviii. v. 10. The MANES OR GHOST apppears lingering and fearful, and wifhes to drag after him a part of his mortal garment, which however adheres to the fide of the portal through which he has paffed. The beauty of this allegory would have been expreffed by Mr. Pope, by "We feel the ruling paffion ftrong in death."

A little lower down in the group the manes or ghoft is received by a beautiful female, a fymbol of IMMORTAL LIFE. This is evinced by her fondling between her knees a large and playful ferpent, which from its annually renewing its external fkin has from great antiquity, even as early as the fable of Prometheus, been efteemed an emblem of

renovated youth. The ſtory of the ſerpent acquiring immortal life from the aſs of Prometheus, who carried it on his back, is told in Bacon's Works, Vol. V. p. 462. Quarto edit. Lond. 1778. For a ſimilar purpoſe a ſerpent was wrapped round the large hieroglyphic egg in the temple of Dioſcuri, as an emblem of the renewal of life from a ſtate of death. Bryant's Mythology, Vol II. p. 359. ſec. edit. On this account alſo the ſerpent was an attendant on Æſculapius, which ſeems to have been the name of the hieroglyphic figure of medicine. This ſerpent ſhews this figure to be an emblem, as the torch ſhewed the central figure of the other compartment to be an emblem, hence they agreeably correſpond, and explain each other, one repreſenting MORTAL LIFE, and the other IMMORTAL LIFE.

This emblematic figure of immortal life ſits down with her feet towards the figure of Pluto, but, turning back her face towards the timid ghoſt, ſhe ſtretches forth her hand, and taking hold of his elbow, ſupports his tottering ſteps, as well as encourages him to advance, both which circumſtances are thus with wonderful ingenuity brought to the eye. At the ſame time the ſpirit looſely lays his hand upon her arm, as one walking in the dark would naturally do for the greater certainty of following his conductreſs, while the general part of the ſymbol of IMMORTAL LIFE, being turned toward the figure of Pluto, ſhews that ſhe is leading the phantom to his realms.

In the Pamphili gardens at Rome, Perſeus in aſſiſting Andromeda to deſcend from the rock takes hold of her elbow to ſteady or ſupport her ſtep, and ſhe lays her hand looſely on his arm as in this figure. Admir. Roman. Antiq.

The figure of PLUTO can not be miſtaken, as is agreed by moſt of the writers who have mentioned this vaſe; his griſley beard, and his having one foot buried in the earth, denotes the infernal monarch. He is placed at the loweſt part of the group, and reſting his chin on his hand, and his arm upon his knee, receives the ſtranger-ſpirit with inquiſitive attention; it was before obſerved that when people think attentively they naturally reſt their bodies in ſome eaſy attitude, that more animal power may be employed on the thinking faculty. In this group of figures there is great art ſhewn in giving an idea of a deſcending plain, viz. from earth to Elyſium, and yet all the figures are in reality on an horizontal one. This wonderful deception is produced firſt by the deſcending ſtep of the manes or ghoſt; ſecondly, by the arm of the ſitting figure of immortal life being raiſed up to receive him as he deſcends; and laſtly, by Pluto having one foot ſunk into the earth.

There is yet another figure which is concerned in conducting the manes or ghoſt to the realms of Pluto, and this is LOVE. He precedes the deſcending ſpirit on expanded wings, lights him with his torch, and turning back his beautiful countenance beckons him to advance. The antient God of love was of much higher dignity than the modern Cupid. He was the firſt that came out of the great egg of night, (Heſiod. Theog. V. CXX. Bryant's Mythol. Vol. II. p. 348.) and is ſaid to poſſeſs the keys of the ſky, ſea, and earth. As he therefore led the way into this life he ſeems to conſtitute a proper emblem for leading the way to a future life. See Bacon's works. Vol. I. p. 568. and Vol. III. p. 582. Quarto edit.

The introduction of love into this part of the mysteries requires a little further explanation. The Psyche of the Ægyptians was one of their most favourite emblems, and represented the soul, or a future life; it was originally no other than the aurelia, or butterfly, but in after times was represented by a lovely female child with the beautiful wings of that insect. The aurelia, after its first stage as an eruca or caterpillar, lies for a season in a manner dead, and is inclosed in a sort of coffin, in this state of darkness it remains all the winter, but at the return of spring it bursts its bonds and comes out with new life, and in the most beautiful attire. The Ægyptians thought this a very proper picture of the soul of man, and of the immortality to which it aspired. But as this was all owing to divine Love, of which EROS was an emblem, we find this person frequently introduced as a concomitant of the soul in general or Psyche. (Bryant's Mythol. Vol. II. p. 386.) EROS, or divine Love, is for the same reason a proper attendant on the manes or soul after death, and much contributes to tell the story, that is, to shew that a soul or manes is designed by the descending figure. From this figure of Love M. D'Hancarville imagines that Orpheus and Eurydice are typified under the figure of the manes and immortal life as above described. It may be sufficient to answer, first, that Orpheus is always represented with a lyre, of which there are prints of four different gems in Spence's Polymetis, and Virgil so describes him, Æn. VI. cytharâ fretus. And secondly, that it is absurd to suppose that Eurydice was fondling and playing with a serpent that had slain her. Add to this that Love seems to have been an inhabitant of the infernal regions, as exhibited in the mysteries, for Claudian, who treats more openly of the Eleusinian mysteries, when they were held in less veneration, invokes the deities to disclose to him their secrets, and amongst other things by what torch Love softens Pluto.

Dii, quibus in numerum, &c.
Vos mihi sacrarum penetralia pandite rerum,
Et vestri secreta poli, quâ lampade Ditem
Flexit amor.

In this compartment there are two trees, whose branches spread over the figures, one of them has smoother leaves like some evergreens, and might thence be supposed to have some allusion to immortality, but they may perhaps have been designed only as ornaments, or to relieve the figures, or because it was in groves, where these mysteries were originally celebrated. Thus Homer speaks of the woods of Proserpina, and mentions many trees in Tartarus, as presenting their fruits to Tantalus; Virgil speaks of the pleasant groves of Elysium; and in Spence's Polymetis there are prints of two antient gems, one of Orpheus charming Cerberus with his lyre, and the other of Hercules binding him in a cord, each of them standing by a tree. Polymet. p. 284. As however these trees have all different foliage so clearly marked by the artist, they may have had specific meanings in the exhibitions of the mysteries, which have not reached posterity, of this kind seem to have been the tree of knowledge of good and evil, and the tree of life, in sacred writ, both which must have been emblematic or allegorical. The masks,

hanging to the handles of the vase, seem to indicate that there is a concealed meaning in the figures besides their general appearance. And the priestess at the bottom, which I come now to describe, seems to shew this concealed meaning to be of the sacred or Eleusinian kind.

3. The figure on the bottom of the vase is on a larger scale than the others, and less finely finished, and less elevated; and as this bottom part was afterwards cemented to the upper part, it might be executed by another artist for the sake of expedition, but there seems no reason to suppose that it was not originally designed for the upper part of it as some have conjectured. As the mysteries of Ceres were celebrated by female priests, for Porphyrius says the antients called the priestesses of Ceres, Melissai, or bees, which were emblems of chastity. Div. Leg. Vol. I. p. 235. And as, in his Satire against the sex, Juvenal says, that few women are worthy to be priestesses of Ceres. Sat. VI. the figure at the bottom of the vase would seem to represent a PRIESTESS or HIEROPHANT, whose office it was to introduce the initiated, and point out to them, and explain the exhibitions in the mysteries, and to exclude the uninitiated, calling out to them, "Far, far retire, ye profane!" and to guard the secrets of the temple. Thus the introductory hymn sung by the hierophant, according to Eusebius, begins, "I will declare a secret to the initiated, but let the doors be shut against the profane." Div. Leg. Vol. I. p. 177. The priestess or hierophant appears in this figure with a close hood, and dressed in linen, which sits close about her; except a light cloak, which flutters in the wind. Wool, as taken from slaughtered animals, was esteemed profane by the priests of Ægypt, who were always dressed in linen. Apuleus, p. 64. Div. Leg. Vol. I. p. 318. Thus Eli made for Samuel a linen ephod. Samuel i. 3.

Secrecy was the foundation on which all mysteries rested, when publicly known they ceased to be mysteries; hence a discovery of them was not only punished with death by the Athenian law; but in other countries a disgrace attended the breach of a solemn oath. The priestess in the figure before us has her finger pointing to her lips as an emblem of silence. There is a figure of Harpocrates, who was of Ægyptian origin, the same as Orus, with the lotus on his head, and with his finger pointing to his lips not pressed upon them, in Bryant's Mythol. Vol. II. p. 398, and another female figure standing on a lotus, as if just risen from the Nile, with her finger in the same attitude, these seem to have been representations or emblems of male and female priests of the secret mysteries. As these sort of emblems were frequently changed by artists for their more elegant exhibition, it is possible the foliage over the head of this figure may bear some analogy to the lotus above mentioned.

This figure of secrecy seems to be here placed, with great ingenuity, as a caution to the initiated, who might understand the meaning of the emblems round the vase, not to divulge it. And this circumstance seems to account for there being no written explanation extant, and no tradition concerning these beautiful figures handed down to us along with them.

Another explanation of this figure at the bottom of the vase would seem to confirm the idea that the basso relievos round its sides are representations of a part of the







The Handles & Bottom of the Vase

myſteries, I mean that it is the head of ATIS. Lucian ſays that Atis was a young man of Phrygia, of uncommon beauty, that he dedicated a temple in Syria to Rhea, or Cybele, and firſt taught her myſteries to the Lydians, Phrygians, and Samothracians, which myſteries he brought from India. He was afterwards made an eunuch by Rhea, and lived like a woman, and aſſumed a feminine habit, and in that garb went over the world teaching her ceremonies and myſteries. Dict. par M. Danet, art. Atis. As this figure is covered with clothes, while thoſe on the ſides of the vaſe are naked, and has a Phrygian cap on the head, and as the form and features are ſo ſoft, that it is difficult to ſay whether it be a male or female figure, there is reaſon to conclude, 1. that it has reference to ſome particular perſon of ſome particular country; 2. that this perſon is Atis, the firſt great hierophant, or teacher of myſteries, to whom M. De la Chauſſe ſays the figure itſelf bears a reſemblance. Muſeo. Capitol. Tom. IV. p. 402.

In the Muſeum Etruſcum, Vol. I. plate 96, there is the head of Atis with feminine features, clothed with a Phrygian cap, and riſing from very broad foliage, placed on a kind of term ſupported by the paw of a lion. Goreus in his explanation of the figure ſays that it is placed on a lion's foot becauſe that animal was ſacred to Cybele, and that it riſes from very broad leaves becauſe after he became an eunuch he determined to dwell in the groves. Thus the foliage, as well as the cap and feminine features, confirm the idea of this figure at the bottom of the vaſe repreſenting the head of Atis the firſt great hierophant, and that the figures on the ſides of the vaſe are emblems from the antient myſteries.

I beg leave to add that it does not appear to have been uncommon amongſt the antients to put allegorical figures on funeral vaſes. In the Pamphili palace at Rome there is an elaborate repreſentation of Life and of Death, on an antient ſarcophagus. In the firſt Prometheus is repreſented making man, and Minerva is placing a butterfly, or the ſoul, upon his head. In the other compartment Love extinguiſhes his torch in the boſom of the dying figure, and is receiving the butterfly, or Pſyche, from him, with a great number of complicated emblematic figures grouped in very bad taſte. Admir. Roman. Antiq.

NOTE XXIII.——COAL.

Whence sable Coal his massy couch extends,
And stars of gold the sparkling Pyrite blends. CANTO II. l. 349.

TO elucidate the formation of coal-beds I shall here describe a fountain of fossil tar, or petroleum, discovered lately near Colebrook Dale in Shropshire, the particulars of which were sent me by Dr. Robert Darwin of Shrewsbury.

About a mile and a half below the celebrated iron-bridge, constructed by the late Mr. DARBY near Colebrook Dale, on the east side of the river Severn, as the workmen in October 1786 were making a subterranean canal into the mountain, for the more easy acquisition and conveyance of the coals which lie under it, they found an oozing of liquid bitumen, or petroleum; and as they proceeded further cut through small cavities of different sizes from which the bitumen issued. From ten to fifteen barrels of this fossil tar, each barrel containing thirty-two gallons, were at first collected in a day, which has since however gradually diminished in quantity, so that at present the product is about seven barrels in fourteen days.

The mountain, into which this canal enters, consists of siliceous sand, in which however a few marine productions, apparently in their recent state, have been found, and are now in the possession of Mr. WILLIAM REYNOLDS of Ketly Bank. About three hundred yards from the entrance into the mountain, and about twenty-eight yards below the surface of it, the tar is found oozing from the sand-rock above into the top and sides of the canal.

Beneath the level of this canal a shaft has been sunk through a grey argillaceous substance, called in this country clunch, which is said to be a pretty certain indication of coal; beneath this lies a stratum of coal, about two or three inches thick, of an inferior kind, yielding little flame in burning, and leaving much ashes; below this is a rock of a harder texture; and beneath this are found coals of an excellent quality; for the purpose of procuring which with greater facility the canal, or horizontal aperture, is now making into the mountain. July, 1788.

Beneath these coals in some places is found salt water, in other parts of the adjacent country there are beds of iron-stone, which also contain some bitumen in a less fluid state, and which are about on a level with the new canal, into which the fossil tar oozes, as above described.

There are many interesting circumstances attending the situation and accompaniments of this fountain of fossil tar, tending to develop the manner of its production. 1. As the canal passing into the mountain runs over the beds of coals, and under the reservoir of petroleum, it appears that a *natural distillation* of this fossil in the bowels of the earth must have taken place at some early period of the world, similar to the artificial distillation

of coal, which has many years been carried on in this place on a smaller scale above ground. When this reservoir of petroleum was cut into, the slowness of its exsudation into the canal was not only owing to its viscidity, but to the pressure of the atmosphere, or to the necessity there was that air should at the same time insinuate itself into the small cavities from which the petroleum descended. The existence of such a distillation at some antient time is confirmed by the thin stratum of coal beneath the canal, (which covers the hard rock,) having been deprived of its fossil oil, so as to burn without flame, and thus to have become a natural coak, or fossil charcoal, while the petroleum distilled from it is found in the cavities of the rock above it.

There are appearances in other places, which favour this idea of the natural distillation of petroleum, thus at Matlock in Derbyshire a hard bitumen is found adhering to the spar in the clefts of the lime-rocks in the form of round drops about the size of peas; which could perhaps only be deposited there in that form by sublimation.

2. The second deduction, which offers itself, is, that these beds of coal have been *exposed to a considerable degree of heat*, since the petroleum above could not be separated, as far as we know, by any other means, and that the good quality of the coals beneath the hard rock was owing to the impermeability of this rock to the bituminous vapour, and to its pressure being too great to permit its being removed by the elasticity of that vapour. Thus from the degree of heat, the degree of pressure, and the permeability of the superincumbent strata, many of the phenomena attending coal-beds receive an easy explanation, which much accords with the ingenious theory of the earth by Dr. Hutton. Transf. of Edinb. Vol. I.

In some coal works the fusion of the strata of coal has been so slight, that there remains the appearance of ligneus fibres, and the impression of leaves, as at Bovey near Exeter, and even seeds of vegetables, of which I have had specimens from the collieries near Polesworth in Warwickshire. In some, where the heat was not very intense and the incumbent stratum not permeable to vapour, the fossil oil has only risen to the upper part of the coal-bed, and has rendered that much more inflammable than the lower parts of it, as in the collieries near Beaudesert, the seat of the EARL OF UXBRIDGE in Staffordshire, where the upper stratum is a perfect cannel, or candle-coal, and the lower one of an inferior quality. Over the coal-beds near Sir H. HARPUR's house in Derbyshire a thin lamina of asphaltum is found in some places near the surface of the earth, which would seem to be from a distillation of petroleum from the coals below, the more fluid part of which had in process of time exhaled, or been consolidated by its absorption of air. In other coal-works the upper part of the stratum is of a worse kind than the lower one, as at Alfreton and Denbigh in Derbyshire, owing to the superincumbent stratum having permitted the exhalation of a great part of the petroleum; whilst at Widdrington in Northumberland there is first a seam of coal about six inches thick of no value, which lies under about four fathom of clay, beneath this is a white freestone, then a hard stone, which the workmen there call a whin, then two fathoms of clay, then another white stone, and under that a vein of coals three feet nine inches

thick, of a ſimilar nature to the Newcaſtle coal. Phil. Tranſ. Abridg. Vol. VI. plate II. p. 192. The ſimilitude between the circumſtances of this colliery, and of the coal beneath the fountain of tar above deſcribed, renders it highly probable that this upper thin ſeam of coal has ſuffered a ſimilar diſtillation, and that the inflammable part of it had either been received into the clay above in the form of ſulphur, which when burnt in the open air would produce alum; or had been diſſipated for want of a receiver, where it could be condenſed. The former opinion is perhaps in this caſe more probable as in ſome other coal-beds, of which I have procured accounts, the ſurface of the coal beneath clunch or clay is of an inferior quality, as at Weſt Hallum in Nottinghamſhire. The clunch probably from hence acquires its inflammable part, which on calcination becomes vitriolic acid. I gathered pieces of clunch converted partially into alum at a colliery near Bilſton, where the ground was ſtill on fire a few years ago.

The heat, which has thus pervaded the beds of moraſs, ſeems to have been the effect of the fermentation of their vegetable materials; as new hay ſometimes takes fire even in ſuch very ſmall maſſes from the ſugar it contains, and ſeems hence not to have been attended with any expulſion of lava, like the deeper craters of volcanos ſituated in beds of granite.

3. The marine ſhells found in the looſe ſand-rock above this reſervoir of petroleum, and the coal-beds beneath it, together with the exiſtence of ſea-ſalt beneath theſe coals, prove that theſe coal beds have been *at the bottom of the ſea*, during ſome remote period of time, and were afterwards raiſed into their preſent ſituation by ſubterraneous expanſions of vapour. This doctrine is further ſupported by the marks of violence, which ſome coal-beds received at the time they were raiſed out of the ſea, as in the collieries at Mendip in Somerſetſhire. In theſe there are ſeven ſtrata of coals, equidiſtant upon each other, with beds of clay and ſtone intervening; amongſt which clay are found ſhells and fern branches. In one part of this hill the ſtrata are disjoined, and a quantity of heterogeneous ſubſtances fill up the chaſm, which disjoins them, on one ſide of this chaſm the ſeven ſtrata of coal are ſeen correſponding in reſpect to their reciprocal thickneſs and goodneſs with the ſeven ſtrata on the other ſide of the cavity, except that they have been elevated ſeveral yards higher. Phil. Tranſ. No. 360. abridg. Vol. V. p. 237.

The cracks in the coal-bed near Ticknall in Derbyſhire, and in the ſand-ſtone rock over it, in both of which ſpecimens of lead-ore and ſpar are found, confirm this opinion of their having been forcibly raiſed up by ſubterraneous fires. Over the colliery at Brown-hills near Lichfield, there is a ſtratum of gravel on the ſurface of the ground; which may be adduced as another proof to ſhew that thoſe coals had ſome time been beneath the ſea, or the bed of a river. Neverthelefs, theſe arguments only apply to the collieries above mentioned, which are few compared with thoſe which bear no marks of having been immerſed in the ſea.

On the other hand the production of coals from moraſſes, as deſcribed in note XX. is evinced from the vegetable matters frequently found in them, and in the ſtrata over them; as fern-leaves in nodules of iron-ore, and from the bog-ſhells or freſh water

muscles sometimes found over them, of both which I have what I believe to be specimens; and is further proved from some parts of these beds being only in part transformed to coal; and the other part still retaining not only the form, but some of the properties of wood; specimens of which are not unfrequent in the cabinets of the curious, procured from Loch Neigh in Ireland, from Bovey near Exeter, and other places; and from a famous cavern called the Temple of the Devil, near the town of Altorf in Franconia, at the foot of a mountain covered with pine and savine, in which are found large coals resembling trees of ebony; which are so far mineralized as to be heavy and compact; and so to effloresce with pyrites in some parts as to crumble to pieces; yet from other parts white ashes are produced on calcination, from which *fixed alcali* is procured; which evinces their vegetable origin. (Dict. Raisonné, art. Charbon.) To these may be added another argument from the oil which is distilled from coals, and which is analogous to vegetable oil, and does not exist in any bodies truly mineral. Keir's Chemical Dictionary, art. Bitumen.

Whence it would appear, that though most collieries with their attendant strata of clay, sand-stone, and iron, were formed on the places where the vegetables grew, from which they had their origin; yet that other collections of vegetable matter were washed down from eminences by currents of waters into the beds of rivers, or the neighbouring seas, and were there accumulated at different periods of time, and underwent a great degree of heat from their fermentation, in the same manner as those beds of morass which had continued on the plains where they were produced. And that by this fermentation many of them had been raised from the ocean with sand and sea-shells over them; and others from the beds of rivers with accumulations of gravel upon them.

4. For the purpose of bringing this history of the products of morasses more distinctly to the eye of the reader, I shall here subjoin two or three accounts of sinking or boring for coals, out of above twenty which I have procured from various places, though the terms are not very intelligible, being the language of the overseers of coal-works.

1. *Whitfield mine* near the Pottery in Staffordshire. Soil 1 foot. brick-clay 3 feet. shale 4. metal which is hard brown and falls in the weather 42. coal 3. warrant clay 6. brown gritstone 36. coal 3½. warrant clay 3½. bass and metal 53½. hardstone 4. shaly bass 1½. coal 4. warrant clay, depth unknown. in all about 55 yards.

2. *Coal-mine at Alfreton* in Derbyshire. Soil and clay 7 feet. fragments of stone 9. bind 13. stone 6. bind 34. stone 5. bind 2. stone 2. bind 10. coal 1½. bind 1½. stone 37. bind 7. soft coal 3. bind 3. stone 20. bind 16. coal 7½. in all about 61 yards.

3. *A basset coal-mine at Woolarton* in Nottinghamshire. Sand and gravel 6 feet. bind 21. stone 10. smut or effete coal 1. clunch 4. bind 21. stone 18. bind 18. stone-bind 15. soft coal 2. clunch and bind 21. coal 7. in all about 48 yards.

4. *Coal-mine at West-Hallam* in Nottinghamshire. Soil and clay 7 feet. bind 48. smut 1½. clunch 4. bind 3. stone 2. bind 1. stone 1. bind 3. stone 1. bind 16. shale 2. bind 12. shale 3. clunch, stone, and a bed of cank 54. soft coal 4. clay and dun 1. soft coal 4½. clunch and bind 21. coal 1. broad bind 26. hard coal 6. in all about 74 yards.

As thefe ftrata generally lie inclined, I fuppofe parallel with the limeftone on which they reft, the upper edges of them all come out to day, which is termed baffetting; when the whole mafs was ignited by its fermentation, it is probable that the inflammable part of fome ftrata might thus more eafily efcape than of others in the form of vapour; as dews are known to flide between fuch ftrata in the production of fprings; which accounts for fome coal-beds being fo much worfe than others. See note XX.

NOTE XXIV.— GRANITE.

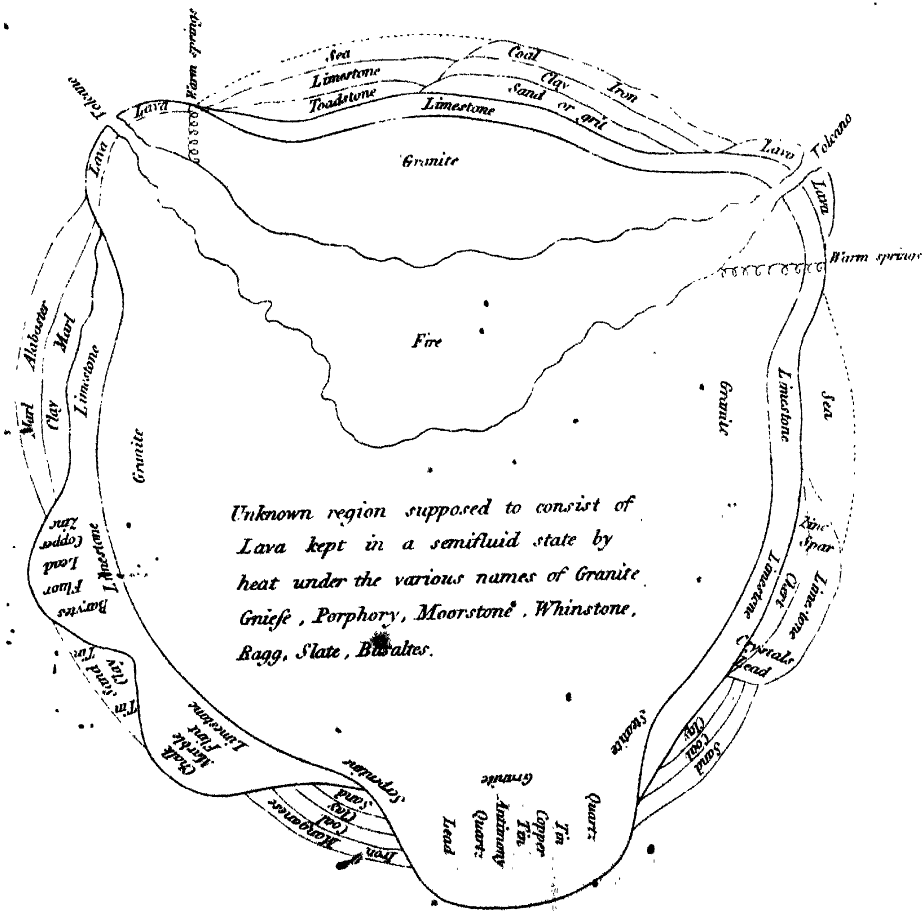
Climb the rude fteeps, the Granite-cliffs furround. CANTO II. l. 522.

THE loweft ftratum of the earth which human labour has arrived to, is granite; and of this likewife confifts the higheft mountains of the world. It is known under variety of names according to fome difference in its appearance or compofition, but is now generally confidered by philofophers as a fpecies of lava; if it contains quartz, feltfpat, and mica in diftinct cryftals, it is called granite; which is found in Cornwall in rocks; and in loofe ftones in the gravel near Drayton in Shropfhire, in the road towards Newcaftle. If thefe parts of the compofition be lefs diftinct, or if only two of them be vifible to the eye, it is termed porphyry, trap, whinftone, moorftone, flate. And if it appears in a regular angular form, it is called bafaltes. The affinity of thefe bodies has lately been further well eftablifhed by Dr. Beddoes in the Phil. Tranf. Vol. LXXX.

Thefe are all efteemed to have been volcanic productions that have undergone different degrees of heat; it is well known that in Papin's digefter water may be made red hot by confinement, and will then diffolve many bodies which otherwife are little or not at all acted upon by it. From hence it may be conceived, that under immenfe preffure of fuperincumbent materials, and by great heat, thefe maffes of lava may have undergone a kind of aqueous folution, without any tendency to vitrification, and might thence have a power of cryftallization, whence all the varieties above mentioned from the different proportion of the materials, or the different degrees of heat they may have undergone in this aqueous folution. And that the uniformity of the mixture of the original earths, as of lime, argil, filex, magnefia, and barytes, which they contain, was owing to their boiling together a longer or fhorter time before their elevation into mountains. See note XIX. art. 8.

The feat of volcanos feems to be principally, if not entirely, in thefe ftrata of granite; as many of them are fituated on granite mountains, and throw up from time to time fheets of lava which run down over the preceeding ftrata from the fame origin; and in this they feem to differ from the heat which has feparated the clay, coal, and fand in moraffes, which would appear to have rifen from a kind of fermentation, and thus to have pervaded the whole mafs without any expuition of lava.

Section of the Earth.



...etch of a supposed Section of the Earth in respect to the disposition ... Strata over each other without regard to their proportions or number.

London, Published Decr. 1st 1791, by J. Johnson, St Pauls Church Yard.

T. Conder Sculpt.

All the lavas from Veſuvius contain one fourth part of iron, (Kirwan's Min.) and all the five primitive earths, viz. calcareous, argillaceous, ſiliceous, barytic, and magneſian earths, which are alſo evidently produced now daily from the recrements of animal and vegetable bodies. What is to be thence concluded? Has the granite ſtratum in very antient times been produced like the preſent calcareous and ſiliceous maſſes, according to the ingenious theory of Dr. Hutton, who ſays new continents are now forming at the bottom of the ſea to riſe in their turn, and that thus the terraqueous globe has been, and will be, eternal? Or ſhall we ſuppoſe that this internal heated maſs of granite, which forms the nucleus of the earth, was a part of the body of the ſun before it was ſeparated by an exploſion? Or was the ſun originally a planet, inhabited like ours, and a ſatellite to ſome other greater ſun, which has long been extinguiſhed by diffuſion of its light, and around which the preſent ſun continues to revolve, according to a conjecture of the celebrated Mr. Herſchell, and which conveys to the mind a moſt ſublime idea of the progreſſive and increaſing excellence of the works of the Creator of all things?

For the more eaſy comprehenſion of the facts and conjectures concerning the ſituation and production of the various ſtrata of the earth, I ſhall here ſubjoin a ſuppoſed ſection of the globe, but without any attempt to give the proportions of the parts, or the number of them, but only their reſpective ſituation over each other, and a geological recapitulation.

GEOLOGICAL RECAPITULATION.

1. The earth was projected along with the other primary planets from the ſun, which is ſuppoſed to be on fire only on its ſurface, emitting light without much internal heat like a ball of burning camphor.

2. The rotation of the earth round its axis was occaſioned by its greater friction or adheſion to one ſide of the cavity from which it was ejected; and from this rotation it acquired its ſpheroidical form. As it cooled in its aſcent from the ſun its nucleus became harder; and its attendant vapours were condenſed, forming the ocean.

3. The maſſes or mountains of granite, porphery, baſalt, and ſtones of ſimilar ſtructure, were a part of the original nucleus of the earth; or conſiſt of volcanic productions ſince formed.

4. On this nucleus of granite and baſaltes, thus covered by the ocean, were formed the calcareous beds of limeſtone, marble, chalk, ſpar, from the exuviæ of marine animals; with the flints, or chertz, which accompany them. And were ſtratified by their having been formed at different and very diſtant periods of time.

5. The whole terraqueous globe was burſt by central fires; iſlands and continents were raiſed, conſiſting of granite or lava in ſome parts, and of limeſtone in others; and great vallies were ſunk, into which the ocean retired.

6. During theſe central earthquakes the moon was ejected from the earth, cauſing new tides; and the earth's axis ſuffered ſome change in its inclination, and its rotatory motion was retarded.

7. On ſome parts of theſe iſlands and continents of granite or limeſtone were gradually produced extenſive moraſſes from the recrements of vegetables and of land animals; and from theſe moraſſes, heated by fermentation, were produced clay, marle, ſandſtone, coal, iron, (with the baſes of variety of acids;) all which were ſtratified by their having been formed at different, and very diſtant periods of time.

8. In the elevation of the mountains very numerous and deep fiſſures neceſſarily were produced. In theſe fiſſures many of the metals are formed partly from deſcending materials, and partly from aſcending ones raiſed in vapour by ſubterraneous fires. In the fiſſures of granite or porphery quartz is formed; in the fiſſures of limeſtone calcareous ſpar is produced.

9. During theſe firſt great volcanic fires it is probable the atmoſphere was either produced, or much increaſed; a proceſs which is perhaps now going on in the moon; Mr. Herſchell having diſcovered a volcanic crater three miles broad burning on her diſk.

10. The ſummits of the new mountains were cracked into innumerable lozenges by the cold dews or ſnows falling upon them when red hot. From theſe ſummits, which were then twice as high as at preſent, cubes and lozenges of granite, and baſalt, and quartz in ſome countries, and of marble and flints in others, deſcended gradually into the valleys, and were rolled together in the beds of rivers, (which were then ſo large as to occupy the whole valleys, which they now only interſect;) and produced the great beds of gravel, of which many valleys conſiſt.

11. In ſeveral parts of the earth's ſurface ſubſequent earthquakes, from the fermentation of moraſſes, have at different periods of time deranged the poſition of the matters above deſcribed. Hence the gravel, which was before in the beds of rivers, has in ſome places been raiſed into mountains, along with clay and coal ſtrata which were formed from moraſſes and waſhed down from eminences into the beds of rivers or the neighbouring ſeas, and in part raiſed again with gravel or marine ſhells over them; but this has only obtained in few places compared with the general diſtribution of ſuch materials. Hence there ſeem to have exiſted two ſources of earthquakes, which have occurred at great diſtance of time from each other; one from the granite beds in the central parts of the earth, and the other from the moraſſes on its ſurface. All the ſubſequent earthquakes and volcanos of modern days compared with theſe are of ſmall extent and inſignificant effect.

12. Beſides the argillaceous ſand-ſtone produced from moraſſes, which is ſtratified with clay, and coal, and iron, other great beds of ſiliceous ſand have been formed in the ſea by the combination of an unknown acid from moraſſes, and the calcareous matters of the ocean.

13. The warm waters which are found in many countries, are owing to ſteam ariſing from great depths through the fiſſures of limeſtone, or lava, elevated by ſubterranean fires, and condenſed between the ſtrata of the hills over them; and not from any decompoſition of pyrites or manganeſe near the ſurface of the earth.

14. The columns of baſaltes have been raiſed by the congelation or expanſion of granite beds in the act of cooling from their ſemi-vitreous fuſion.

NOTE XXV.——EVAPORATION.

Aquatic nymphs! you lead with viewlefs march
The winged vapour up the aerial arch. CANTO III. l. 13.

I. THE atmofphere will diffolve a certain quantity of moifture as a chemical menftruum, even when it is much below the freezing point, as appears from the diminution of ice fufpended in frofty air, but a much greater quantity of water is evaporated and fufpended in the air by means of heat, which is perhaps the univerfal caufe of fluidity, for water is known to boil with lefs heat in vacuo, which is a proof that it will evaporate fafter in vacuo, and that the air therefore rather hinders than promotes its evaporation in higher degrees of heat. The quick evaporation occafioned in vacuo by a fmall degree of heat is agreeably feen in what is termed a pulfe-glafs, which confifts of an exhaufted tube of glafs with a bulb at each end of it and with about two thirds of the cavity filled with alcohol, in which the fpirit is inftantly feen to boil by the heat of the finger-end applied on a bubble of fteam in the lower bulb, and is condenfed again in the upper bulb by the leaft conceivable comparative coldnefs.

2. Another circumftance evincing that heat is the principal caufe of evaporation is that at the time of water being converted into fteam, a great quantity of heat is taken away from the neighbouring bodies. If a thermometer be repeatedly dipped in ether, or in rectified fpirit of wine, and expofed to a blaft of air, to expedite the evaporation by perpetually removing the faturated air from it, the thermometer will prefently fink below freezing. This warmth, taken from the ambient bodies at the time of evaporation by the fteam, is again given out when the fteam is condenfed into water. Hence the water in a worm-tub during diftillation fo foon becomes hot; and hence the warmth accompanying the defcent of rain in cold weather.

3. The third circumftance, fhewing that heat is the principal caufe of evaporation, is, that fome of the fteam becomes again condenfed when any part of the heat is withdrawn. Thus when warmer fouth-weft winds replete with moifture fucceed the colder north-eaft winds all bodies that are denfe and fubftantial, as ftone walls, brick floors, &c. abforb fome of the heat from the paffing air, and its moifture becomes precipitated on them, while the north-eaft winds become warmer on their arrival in this latitude, and are thence difpofed to take up more moifture, and are termed drying winds.

4. Heat feems to be the principal caufe of the folution of many other bodies, as common falt, or blue vitriol diffolved in water, which when expofed to fevere cold are precipitated or carried to the part of the water laft frozen; this I obferved in a phial filled with a folution of blue vitriol which was frozen; the phial was burft, the ice

thawed, and a blue column of cupreous vitriol was left ſtanding upright on the bottom of the broken glaſs, as deſcribed in note XIX.

II. Hence water may either be diſſolved in air, and may then be called an aerial ſolution of water; or it may be diſſolved in the fluid matter of heat, according to the theory of M. Lavoiſier, and may then be called ſteam. In the former caſe it is probable there are many other vapours which may precipitate it, as marine acid gas, or fluor acid gas. So alcaline gas and acid gas diſſoved in air precipitate each other, nitrous gas precipitates vital air from its azote, and inflammable gas mixed with vital air ignited by an electric ſpark either produces or precipitates the water in both of them. Are there any ſubtle exhalations occaſionally diffuſed in the atmoſphere which may thus cauſe rain?

1. But as water is perhaps many hundred times more ſoluble in the fluid matter of heat than in air, I ſuppoſe the eduction of this heat, by whatever means it is occaſioned, is the principal cauſe of devaporation. Thus if a region of air is brought from a warmer climate, as the S. W. winds, it becomes cooled by its contact with the earth in this latitude, and parts with ſo much of its moiſture as was diſſolved in the quantity of calorique, or heat, which it now looſes, but retains that part which was ſuſpended by its attraction to the particles of air, or by aerial ſolution, even in the moſt ſevere froſts.

2. A ſecond immediate cauſe of rain is a ſtream of N. E. wind deſcending from a ſuperior current of air, and mixing with the warmer S. W. wind below; or the reverſe of this, viz. a ſuperior current of S. W. wind mixing with an inferior one of N. E. wind; in both theſe caſes the whole heaven becomes inſtantly clouded, and the moiſture contained in the S. W. current is precipitated. This cauſe of devaporation has been ingeniouſly explained by Dr. Hutton in the Tranſact. of Edinburgh, Vol. I. and ſeems to ariſe from this circumſtance; the particles of air of the N. E. wind educe part of the heat from the S. W. wind, and therefore the water which was diſſolved by that quantity of *heat* is precipitated; all the other part of the water, which was ſuſpended by its attraction to the particles of air, or diſſolved in the remainder of the heat, continues unprecipitated.

3. A third method by which a region of air becomes cooled, and in conſequence depoſits much of its moiſture, is from the mechanical expanſion of air, when part of the preſſure is taken off. In this caſe the expanded air becomes capable of receiving or attracting more of the matter of heat into its interſtices, and the vapour, which was previouſly diſſolved in this heat, is depoſited, as is ſeen in the receiver of an air-pump, which becomes dewy, as the air within becomes expanded by the eduction of part of it. See note VII. Hence when the mercury in the barometer ſinks without a change of the wind the air generally becomes colder. See note VII. on Elementary Heat. And it is probably from the varying preſſure of the incumbent air that in ſummer days ſmall black clouds are often thus ſuddenly produced, and again ſoon vaniſh. See a paper in Philoſ. Tranſ. Vol. LXXVIII. intitled Frigorific Experiments on the Mechanical Expanſion of Air.

4. Another portion of atmofpheric water may poffibly be held in folution by the electric fluid, fince in thunder ftorms a precipitation of the water feems to be either the caufe or the confequence of the eduction of the electricity. But it appears more probable that the water is condenfed into clouds by the eduction of its heat, and that then the furplus of electricity prevents their coalefcence into larger drops, which immediately fucceeds the departure of the lightning.

5. The immediate caufe why the barometer finks before rain is, firft, becaufe a region of warm air, brought to us in the place of the cold air which it had difplaced, muft weigh lighter, both fpecifically and abfolutely, if the height of the warm atmofphere be fuppofed to be equal to that of the preceeding cold one. And fecondly, after the drops of rain begin to fall in any column of air, that column becomes lighter, the falling drops only adding to the preffure of the air in proportion to the refiftance which they meet with in paffing through that fluid.

If we could fuppofe water to be diffolved in air without heat, or in very low degrees of heat, I fuppofe the air would become heavier, as happens in many chemical folutions, but if water diffolved in the matter of heat, or calorique, be mixed with an aerial folution of water, there can be no doubt but an atmofphere confifting of fuch a mixture muft become lighter in proportion to the quantity of calorique. On the fame circumftance depends the vifible vapour produced from the breath of animals in cold weather, or from a boiling kettle; the particles of cold air, with which it is mixed, fteal a part of its heat, and become themfelves raifed in temperature, whence part of the water is precipitated in vifible vapour, which, if in great quantity finks to the ground; if in fmall quantity, and the furrounding air is not previoufly faturated, it fpreads itfelf till it becomes again diffolved.

NOTE XXVI.——SPRINGS.

Your lucid bands condenſe with fingers chill
The blue miſt hovering round the gelid hill. CANTO III. l. 19.

THE ſurface of the earth conſiſts of ſtrata many of which were formed originally beneath the ſea, the mountains were afterwards forced up by ſubterraneous fires, as appears from the fiſſures in the rocks of which they conſiſt, the quantity of volcanic productions all over the world, and the numerous remains of craters of volcanos in mountainous countries. Hence the ſtrata which compoſe the ſides of mountains lie ſlanting downwards, and one or two or more of the external ſtrata not reaching to the ſummit when the mountain was raiſed up, the ſecond or third ſtratum or a more inferior one is there expoſed to day; this may be well repreſented by forceably thruſting a blunt inſtrument through ſeveral ſheets of paper, a bur will ſtand up with the lowermoſt ſheet ſtanding higheſt in the center of it. On this uppermoſt ſtratum, which is colder as it is more elevated, the dews are condenſed in large quantities; and ſliding down paſs under the firſt or ſecond or third ſtratum which compoſe the ſides of the hill; and either form a moraſs below, or a weeping rock, by oozing out in numerous places, or many of theſe leſs currents meeting together burſt out in a more copious rill.

The ſummits of mountains are much colder than the plains in their vicinity, owing to ſeveral cauſes; 1. Their being in a manner inſulated or cut off from the common heat of the earth, which is always of 48 degrees, and perpetually counteracts the effects of external cold beneath that degree. 2. From their ſurfaces being larger in proportion to their ſolid contents, and hence their heat more expeditiouſly carried away by the ever-moving atmoſphere. 3. The increaſing rarity of the air as the mountain riſes. All thoſe bodies which conduct electricity well or ill, conduct the matter of heat likewiſe well or ill. See note VII. Atmoſpheric air is a bad conductor of electricity and thence confines it on the body where it is accumulated, but when it is made very rare, as in the exhauſted receiver, the electric aura paſſes away immediately to any diſtance. The ſame circumſtance probably happens in reſpect to heat, which is thus kept by the denſer air on the plains from eſcaping, but is diſſipated on the hills where the air is thinner. 4. As the currents of air riſe up the ſides of mountains they become mechanically rarefied, the preſſure of the incumbent column leſſening as they aſcend. Hence the expanding air abſorbs heat from the mountain as it aſcends, as explained in note VII. 5. There is another, and perhaps more powerful cauſe, I ſuſpect, which may occaſion the great cold on mountains, and in the higher parts of the atmoſphere, and which has not yet been attended to; I mean that the fluid matter of heat may prodably gravitate round the earth, and form an atmoſphere on its ſurface, mixed with the aerial atmoſphere, which may diminiſh or become rarer, as it recedes from the earth's ſurface, in a greater proportion than the air diminiſhes.

6. The great condenſation of moiſture on the ſummits of hills has another cauſe, which is the daſhing of moving clouds againſt them, in miſty days this is often ſeen to have great effect on plains, where an eminent tree by obſtructing the miſt as it moves along ſhall have a much greater quantity of moiſture drop from its leaves than falls at the ſame time on the ground in its vicinity. Mr. White, in his Hiſtory of Selborne gives an account of a large tree ſo ſituated, from which a ſtream flowed during a moving miſt ſo as to fill the cart-ruts in a lane otherwiſe not very moiſt, and ingeniouſly adds, that trees planted about ponds of ſtagnant water contribute much by theſe means to ſupply the reſervoir. The ſpherules which conſtitute a miſt or cloud are kept from uniting by ſo ſmall a power that a little agitation againſt the leaves of a tree, or the greater attraction of a flat moiſt ſurface, condenſes or precipitates them.

If a leaf has its ſurface moiſtened and particles of water ſeparate from each other as in a miſt be brought near the moiſtened ſurface of a leaf, each particle will be attracted more by that plain ſurface of water on the leaf than it can be by the ſurrounding particles of the miſt, becauſe globules only attract each other in one point, whereas a plain attracts a globule by a greater extent of its ſurface.

The common cold ſprings are thus formed on elevated grounds by the condenſed vapours, and hence are ſtronger when the nights are cold after hot days in ſpring, than even in the wet days of winter. For the warm atmoſphere during the day has diſſolved much more water than it can ſupport in ſolution during the cold of the night, which is thus depoſited in large quantities on the hills, and yet ſo gradually as to ſoak in between the ſtrata of them, rather than to ſlide off over their ſurfaces like ſhowers of rain. The common heat of the internal parts of the earth is aſcertained by ſprings which ariſe from ſtrata of earth too deep to be affected by the heat of ſummer or the froſts of winter. Thoſe in this country are of 48 degrees of heat, thoſe about Philidelphia were ſaid by Dr. Franklin to be 52; whether this variation is to be accounted for by the difference of the ſun's heat on that country, according to the ingenious theory of Mr. Kirwan, or to the vicinity of ſubterranean fires is not yet, I think, decided. There are however ſubterraneous ſtreams of water not exactly produced in this manner, as ſtreams iſſuing from fiſſures in the earth, communicating with the craters of old volcanoes; in the Peak of Derbyſhire are many hollows, called ſwallows, where the land floods ſink into the earth, and come out at ſome miles diſtant, as at Ilam near Aſhborne. See note on Fica, Vol. II.

Other ſtreams of cold water ariſe from beneath the ſnow on the Alps and Andes, and other high mountains, which is perpetualy thawing at its under ſurface by the common heat of the earth, and gives riſe to large rivers. For the origin of warm ſprings ſee note on Fucus, Vol. II.

NOTE XXVII.——SHELL FISH.

You round Echinus ray his arrowy mail,
Give the keel'd Nautilus his oar and ſail.
Firm to his rock with ſilver cords ſuſpend
The anchor'd Pinna, and his Cancer-friend. CANTO III. l. 67.

THE armour of the Echinus, or Sea-hedge Hog, conſiſts generally of moveable ſpines; *(Linnei Syſtem. Nat.* Vol. I. p. 1102.) and in that reſpect reſembles the armour of the land animal of the ſame name. The irregular protuberances on other ſea-ſhells, as on ſome ſpecies of the Purpura, and Murex, ſerve them as a fortification againſt the attacks of their enemies.

It is ſaid that this animal foreſees tempeſtuous weather, and ſinking to the bottom of the ſea adheres firmly to ſea-plants, or other bodies by means of a ſubſtance which reſembles the horns of ſnails. Above twelve hundred of theſe fillets have been counted by which this animal fixes itſelf; and when afloat, it contracts theſe fillets between the baſes of its points, the number of which often amounts to two thouſand. Dict. raiſonne. art. Ourſin. de mer.

There is a kind of Nautilus, called by Linneus, Argonauta, whoſe ſhell has but one cell; of this animal Pliny affirms, that having exonerated its ſhell by throwing out the water, it ſwims upon the ſurface, extending a web of wonderful tenuity, and bending back two of its arms and rowing with the reſt, makes a ſail, and at length receiving the water dives again. Plin. IX. 29. Linneus adds to his deſcription of this animal, that like the the Crab Diogenes or Bernhard, it occupies a houſe not its own, as it is not connected to its ſhell, and is therefore foreign to it; who could have given credit to this if it had not been atteſted by ſo many who have with their own eyes ſeen this argonaut in the act of ſailing? Syſt. Nat. p. 1161.

The Nautilus, properly ſo named by Linneus, has a ſhell conſiſting of many chambers, of which cups are made in the Eaſt with beautiful painting and carving on the mother-pearl. The animal is ſaid to inhabit only the uppermoſt or open chamber, which is larger than the reſt; and that the reſt remain empty except that the pipe, or ſiphunculus, which communicates from one to the other of them is filled with an appendage of the animal like a gut or ſtring. Mr. Hook in his Philoſ. Exper. p. 306, imagines this to be a dilatable or compreſſible tube, like the air-bladders of fiſh, and that by contracting or permitting it to expand, it renders its ſhell boyant or the contrary. See Note on Ulva, Vol. II.

The Pinna, or Sea-wing, is contained in a two-valve ſhell, weighing ſometimes fifteen pounds, and emits a beard of fine long gloſſy ſilk-like fibres, by which it is ſuſpended to the rocks twenty or thirty feet beneath the ſurface of the ſea. In this ſituation it is ſo ſucceſsfully attacked by the eight-footed Polypus, that the ſpecies perhaps could not exiſt

but for the exertions of the Cancer Pinnotheris, who lives in the ſame ſhell as a guard and companion. Amœn. Academ. Vol. II. p. 48. Lin. Syſt. Nat. Vol. I. p. 1159, and p. 1040.

The Pinnotheris, or Pinnophylax, is a ſmall crab naked like Bernard the Hermit, but is furniſhed with good eyes, and lives in the ſame ſhell with the Pinna; when they want food the Pinna opens its ſhell, and ſends its faithful ally to forage; but if the Cancer ſees the Polypus, he returns ſuddenly to the arms of his blind hoſteſs, who by cloſing the ſhell avoids the fury of her enemy; otherwiſe, when it has procured a booty, it brings it to the opening of the ſhell, where it is admitted, and they divide the prey. This was obſerved by Haſlequiſt in his voyage to Paleſtine.

The Byſſus of the antients, according to Ariſtotle, was the beard of the Pinna above mentioned, but ſeems to have been uſed by other writers indiſcriminately for any ſpun material, which was eſteemed finer or more valuable than wool. Reaumur ſays the threads of this Byſſus are not leſs fine or leſs beautiful than the ſilk, as it is ſpun by the ſilk-worm; the Pinna on the coaſts of Italy and Provence (where it is fiſhed up by iron-hooks fixed on long poles) is called the ſilk-worm of the ſea. The ſtockings and gloves manufactured from it, are of exquiſite fineneſs, but too warm for common wear, and are thence eſteemed uſeful in rhumatiſm and gout. Dict. raiſonné art. Pinne-marine. The warmth of the Byſſus, like that of ſilk, is probably owing to their being bad conductors of heat, as well as of electricity. When theſe fibres are broken by violence, this animal as well as the muſcle has the power to reproduce them like the common ſpiders, as was obſerved by M. Adanſon. As raw ſilk, and raw cobwebs, when ſwallowed, are liable to produce great ſickneſs (as I am informed) it is probable the part of muſcles, which ſometimes diſagrees with the people who eat them, may be this ſilky web, by which they attach themſelves to ſtones. The large kind of Pinna contains ſome mother-pearl of a reddiſh tinge, according to M. d'Argenville. The ſubſtance ſold under the name of Indian weed, and uſed at the bottom of fiſh-lines, is probably a production of this kind; which however is ſcarcely to be diſtinguiſhed by the eye from the tendons of a rat's tail, after they have been ſeparated by putrefaction in water, and well cleaned and rubbed; a production, which I was once ſhewn as a great curioſity; it had the uppermoſt bone of the tail adhering to it, and was ſaid to have been uſed as an ornament in a lady's hair.

NOTE XXVIII.——STURGEON.

With worm-like beard his toothleſs lips array,
And teach the unweildy Sturgeon to betray. CANTO III. l. 71.

THE Sturgeon, *Acipenſer, Strurio.* Lin. Syſt. Nat. Vol. I. p. 403. is a fiſh of great curioſity as well as of great importance; his mouth is placed under the head, without teeth, like the opening of a purſe, which he has the power to puſh ſuddenly out or retract. Before this mouth under the beak or noſe hang four tendrils ſome inches long, and which ſo reſemble earth-worms that at firſt ſight they may be miſtaken for them. This clumſy toothleſs fiſh is ſuppoſed by this contrivance to keep himſelf in good condition, the ſolidity of his fleſh evidently ſhewing him to be a fiſh of prey. He is ſaid to hide his large body amongſt the weeds near the ſea-coaſt, or at the mouths of large rivers, only expoſing his cirrhi or tendrils, which ſmall fiſh or ſea-inſects miſtaking for real worms approach for plunder, and are ſucked into the jaws of their enemy. He has been ſuppoſed by ſome to root into the ſoil at the bottom of the ſea or rivers; but the cirrhi, or tendrills abovementioned, which hang from his ſnout over his mouth, muſt themſelves be very inconvenient for this purpoſe, and as it has no jaws it evidently lives by ſuction, and during its reſidence in the ſea a quantity of ſea-inſects are found in its ſtomach.

The fleſh was ſo valued in the time of the Emperor Severus, that it was brought to table by ſervants with coronets on their heads, and preceded by muſic, which might give riſe to its being in our country preſented by the Lord Mayor to the King. At preſent it is caught in the Danube, and the Walga, the Don, and other large rivers for various purpoſes. The ſkin makes the beſt covering for carriages; iſinglaſs is prepared from parts of the ſkin; cavear from the ſpawn; and the fleſh is pickled or ſalted, and ſent all over Europe.

NOTE XXIX.——OIL ON WATER.

Who with fine films, ſuſpended o'er the deep,
Of Oil effuſive lull the waves to ſleep. CANTO III. l. 87.

THERE is reaſon to believe that when oil is poured upon water, the two ſurfaces do not touch each other, but that the oil is ſuſpended over the water by their mutual repulſion. This ſeems to be rendered probable by the following experiment: if one drop of oil be droped on a baſon of water, it will immediately diffuſe itſelf over the whole, for there being no friction between the two ſurfaces, there is nothing to prevent its ſpreading itſelf by the gravity of the upper part of it, except its own tenacity, into a pellicle

of the greateſt tenuity. But if a ſecond drop of oil be put upon the former, it does not ſpread itſelf, but remains in the form of a drop, as the other already occupied the whole ſurface of the baſon, and there is friction in oil paſſing over oil, though none in oil paſſing over water.

Hence when oil is diffuſed on the ſurface of water gentle breezes have no influence in raiſing waves upon it; for a ſmall quantity of oil will cover a very great ſurface of water, (I ſuppoſe a ſpoonful will diffuſe itſelf over ſome acres) and the wind blowing upon this carries it gradually forwards; and there being no friction between the two ſurfaces the water is not affected. On which account oil has no effect in ſtilling the agitation of the water after the wind ceaſes, as was found by the experiments of Dr. Franklin.

This circumſtance lately brought into notice by Dr. Franklin had been mentioned by Pliny, and is ſaid to be in uſe by the divers for pearls, who in windy weather take down with them a little oil in their mouths, which they occaſionally give out when the inequality of the ſupernatant waves prevents them from ſeeing ſufficiently diſtinctly for their purpoſe.

The wonderful tenuity with which oil can be ſpread upon water is evinced by a few drops projected from a bridge, where the eye is properly placed over it, paſſing through all the priſmatic colours as it diffuſes itſelf. And alſo from another curious experiment of Dr. Franklin's: he cut a piece of cork to about the ſize of a letter-wafer, leaving a point ſtanding off like a tangent at one edge of the circle. This piece of cork was then dipped in oil and thrown into a large pond of water, and as the oil flowed off at the point, the cork-wafer continued to revolve in a contrary direction for ſeveral minutes. The oil flowing off all that time at the pointed tangent in coloured ſtreams. In a ſmall pond of water this experiment does not ſo well ſucceed, as the circulation of the cork ſtops as ſoon as the water becomes covered with the pellicle of oil. See Additional Note, No. XIII. and Note on Fucus, Vol. II.

The eaſe with which oil and water ſlide over each other is agreeably ſeen if a phial be about half filled with equal parts of oil and water, and made to oſcillate ſuſpended by a ſtring, the upper ſurface of the oil and the lower one of the water will always keep ſmooth; but the agitation of the ſurfaces where the oil and water meet, is curious; for their ſpecific gravities being not very different, and their friction on each other nothing, the higheſt ſide of the water, as the phial deſcends in its oſcillation, having acquired a greater momentum than the loweſt ſide (from its having deſcended further) would riſe the higheſt on the aſcending ſide of the oſcillation, and thence puſhes the then uppermoſt part of the water amongſt the oil.

NOTE XXX.——SHIP-WORM.

Meet fell Teredo, as he mines the keel
With beaked head, and break his lips of ſteel. CANTO III. l. 91.

THE Teredo, or ſhip-worm, has two calcareous jaws, hemiſpherical, flat before, and angular behind. The ſhell is taper, winding, penetrating ſhips and ſubmarine wood, and was brought from India into Europe, Linnei Syſtem. Nat. p. 1267. The Tarieres, or ſea-worms, attack and erode ſhips with ſuch fury, and in ſuch numbers, as often greatly to endanger them. It is ſaid that our veſſels have not known this new enemy above fifty years, that they were brought from the ſea about the Antilles to our parts of the ocean, where they have increaſed prodigiouſly. They bore their paſſage in the direction of the fibres of the wood, which is their nouriſhment, and cannot return or paſs obliquely, and thence when they come to a knot in the wood, or when two of them meet together with their ſtony mouths, they periſh for want of food.

In the years 1731 and 1732 the United Provinces were under a dreadful alarm concerning theſe inſects, which had made great depredation on the piles which ſupport the banks of Zeland, but it was happily diſcovered a few years afterwards that theſe inſects had totally abandoned that iſland, (Dict. Raiſonné, art. Vers Rongeurs,) which might have been occaſioned by their not being able to live in that latitude when the winter was rather ſeverer than uſual.

NOTE XXXI.——MAELSTROM.

Turn the broad helm, the fluttering canvas urge
From Maelſtrom's fierce innavigable ſurge. CANTO III. l. 93.

ON the coaſt of Norway there is an extenſive vortex, or eddy, which lies between the iſlands of Moſkoe and Moſkenas, and is called Moſkoeſtrom, or Maelſtrom; it occupies ſome leagues in circumference, and is ſaid to be very dangerous and often deſtructive to veſſels navigating theſe ſeas. It is not eaſy to underſtand the exiſtence of a conſtant deſcending ſtream without ſuppoſing it muſt paſs through a ſubterranean cavity to ſome other part of the earth or ocean which may lie beneath its level; as the Mediterranean ſeems to lie beneath the level of the Atlantic ocean which therefore

conſtantly flows into it through the Straits; and the waters of the Gulph of Mexico lie much above the level of the ſea about the Floridas and further northward, which gives riſe to the Gulph-ſtream, as deſcribed in note on Caſſia in Vol. II.

The Maelſtrom is ſaid to be ſtill twice in about twenty-four hours when the tide is up, and moſt violent at the oppoſite times of the day. This is not difficult to account for, ſince when ſo much water is brought over the ſubterraneous paſſage, if ſuch exiſts, as compleatly to fill it and ſtand many feet above it, leſs diſturbance muſt appear on the ſurface. The Maelſtrom is deſcribed in the Memoires of the Swediſh Academy of Sciences, and Pontoppiden's Hiſt. of Norway, and in Univerſal Muſeum for 1763, p. 131.

The reaſon why eddies of water become hollow in the middle is becauſe the water immediately over the centre of the well, or cavity, falls faſter, having leſs friction to oppoſe its deſcent, than the water over the circumference or edges of the well. The circular motion or gyration of eddies depends on the obliquity of the courſe of the ſtream, or to the friction or oppoſition to it being greater on one ſide of the well than the other; I have obſerved in water paſſing through a hole in the bottom of a trough, which was always kept full, the gyration of the ſtream might be turned either way by increaſing the oppoſition of one ſide of the eddy with ones finger, or by turning the ſpout, through which the water was introduced, a little more obliquely to the hole on one ſide or on the other. Lighter bodies are liable to be retained long in eddies of water, while thoſe rather heavier than water are ſoon thrown out beyond the circumference by their acquired momentum becoming greater than that of the water. Thus if equal portions of oil and water be put into a phial, and by means of a ſtring be whirled in a circle round the hand, the water will always keep at the greater diſtance from the centre, whence in the eddies formed in rivers during a flood a perſon who endeavours to keep above water or to ſwim is liable to be detained in them, but on ſuffering himſelf to ſink or dive he is ſaid readily to eſcape. This circulation of water in deſcending through a hole in a veſſel Dr. Franklin has ingeniouſly applied to the explanation of hurricanes or eddies of air.

NOTE XXXII.——GLACIERS.

While round dark crags imprison'd waters bend
Through rifted ice, in ivory veins descend. CANTO III. l. 113.

THE common heat of the interior parts of the earth being always 48 degrees, both in winter and summer, the snow which lies in contact with it is always in a thawing state; Hence in ice-houses the external parts of the collection of ice is perpetually thawing and thus preserves the internal part of it; so that it is necessary to lay up many tons for the preservation of one ton. Hence in Italy considerable rivers have their source from beneath the eternal glaciers, or mountains of snow and ice.

In our country when the air in the course of a frost continues a day or two at very near 32 degrees, the common heat of the earth thaws the ice on its surface, while the thermometer remains at the freezing point. This circumstance is often observable in the rimy mornings of spring; the thermometer shall continue at the freezing point, yet all the rime will vanish, except that which happens to lie on a bridge, a board, or on a cake of cow-dung, which being thus as it were insulated or cut off from so free a communication with the common heat of the earth by means of the air under the bridge, or wood, or dung, which are bad conductors of heat, continues some time longer unthawed. Hence when the ground is covered thick with snow, though the frost continues, and the sun does not shine, yet the snow is observed to decrease very sensibly. For the common heat of the earth melts the under surface of it, and the upper one evaporates by its solution in the air. The great evaporation of ice was observed by Mr. Boyle, which experiment I repeated some time ago. Having suspended a piece of ice by a wire and weighed it with care without touching it with my hand, I hung it out the whole of a clear frosty night, and found in the morning it had lost nearly a fifth of its weight. Mr. N. Wallerius has since observed that ice at the time of its congelation evaporates faster than water in its fluid form; which may be accounted for from the heat given out at the instant of freezing; (Saussure's Essais sur Hygromet. p. 249.) but this effect is only momentary.

Thus the vegetables that are covered with snow are seldom injured; since, as they lie between the thawing snow, which has 32 degrees of heat, and the covered earth which has 48, they are preserved in a degree of heat between these; viz. in 40 degrees of heat. Whence the moss on which the rein-deer feed in the northern latitudes vegetates beneath the snow; (See note on Muschus, Vol. II.) and hence many Lapland and Alpine plants perished through cold in the botanic garden at Upsal, for in their native situations, though the cold is much more intense, yet at its very commencement they are covered deep with snow, which remains till late in the spring. For this fact see Amænit. Academ. Vol. I. No. 48. In our climate such plants do well covered with dried fern, under which they will grow, and even flower, till the severe vernal frosts cease. For the increase of glaciers see Note on Canto I. l. 529.

NOTE XXXIII.——WINDS.

While ſouthern gales o'er weſtern oceans roll,
And Eurus ſteals his ice-winds from the pole. CANTO IV. l. 15.

THE theory of the winds is yet very imperfect, in part perhaps owing to the want of obſervations ſufficiently numerous of the exact times and places where they begin and ceaſe to blow, but chiefly to our yet imperfect knowledge of the means by which great regions of air are either ſuddenly produced or ſuddenly deſtroyed.

The air is perpetually ſubject to increaſe or diminution from its combination with other bodies, or its evolution from them. The vital part of the air, called oxygene, is continually produced in this climate from the perſpiration of vegetables in the ſunſhine, and probably from the action of light on clouds or on water in the tropical climates, where the ſun has greater power, and may exert ſome yet unknown laws of luminous combination. Another part of the atmoſphere, which is called azote, is perpetually ſet at liberty from animal and vegetable bodies by putrefaction or combuſtion, from many ſprings of water, from volatile alcali, and probably from fixed alcali, of which there is an exhauſtleſs ſource in the water of the ocean. Both theſe component parts of the air are perpetually again diminiſhed by their contact with the ſoil, which covers the ſurface of the earth, producing nitre. The oxygene is diminiſhed in the production of all acids, of which the carbonic and muriatic exiſt in great abundance. The azote is diminiſhed in the growth of animal bodies, of which it conſtitutes an important part, and in its combinations with many other natural productions.

They are both probably diminiſhed in immenſe quantities by uniting with the inflammable air, which ariſes from the mud of rivers and lakes at ſome ſeaſons, when the atmoſphere is light: the oxgene of the air producing water, and the azote producing volatile alcali by their combinations with this inflammable air. At other ſeaſons of the year theſe principles may again change their combinations, and the atmoſpheric air be reproduced.

Mr. Lavoiſier found that one pound of charcoal in burning conſumed two pounds nine ounces of vital air, or oxygene. The conſumption of vital air in the proceſs of making red lead may readily be reduced to calculation; a ſmall barrel contains about twelve hundred weight of this commodity, 1200 pounds of lead by calcination abſorb about 144 pounds of vital air; now as a cubic foot of water weighs 1000 averdupois ounces, and as vital air is above 800 times lighter than water, it follows that every barrel of red lead contains nearly 2000 cubic feet of vital air. If this can be performed in miniature in a ſmall oven, what may not be done in the immenſe elaboratories of nature!

Theſe great elaboratories of nature include almoſt all her foſſil as well as her animal and vegetable productions. Dr. Prieſtley obtained air of greater or leſs purity, both

vital and azotic, from almost all the fossil substances he subjected to experiment. Four ounce-weight of lava from Iceland heated in an earthen retort yielded twenty ounce-measures of air.

4	ounce-weight of	lava	gave	20	ounce measures of air.
7	....	basaltes	....	104	....
2	....	toadstone	....	40	....
1½	....	granite	....	20	....
1	....	elvain	....	30	....
7	....	gypsum	....	230	....
4	....	blue slate	....	230	....
4	....	clay	....	20	....
4	....	limestone-spar	....	830	....
5	....	limestone	....	1160	....
3	....	chalk	....	630	....
3½	....	white iron-ore	....	560	....
4	....	dark iron-ore	....	410	....
½	....	molybdena	....	25	....
¼	....	stream tin	....	20	....
2	....	steatites	....	40	....
2	....	barytes	....	26	....
2	....	black wad	....	80	....
4	....	sand stone	....	75	....
3	....	coal	....	700	....

In this account the fixed air was previously extracted from the limestones by acids, and the heat applied was much less than was necessary to extract all the air from the bodies employed. Add to this the known quantities of air which are combined with the calciform ores, as the ochres of iron, manganese, calamy, grey ore of lead, and some idea may be formed of the great production of air in volcanic eruptions, as mentioned in note on Chunda, Vol. II. and of the perpetual absorptions and evolutions of whole oceans of air from every part of the earth.

But there would seem to be an officina aëris, a shop where air is both manufactured and destroyed in the greatest abundance within the polar circles, as will hereafter be spoken of. Can this be effected by some yet unknown law of the congelation of aqueous or saline fluids, which may set at liberty their combined heat, and convert a part both of the acid and alcali of sea-water into their component airs? Or on the contrary can the electricity of the northern lights convert inflammable air and oxygene into water, whilst the great degree of cold at the poles unites the azote with some other base? Another officina aeris, or manufacture of air, would seem to exist within the tropics or at the line, though in a much less quantity than at the poles, owing perhaps to the action of the sun's light on the moisture suspended in the air, as will also be spoken of hereafter; but in all other parts of the earth these absorptions and evolutions of air in a greater or less degree are perpetually going on in inconceivable abundance; increased probably, and diminished at different seasons of the year by the approach or recession of the sun's light; future discoveries must elucidate this part of the subject. To this should be added

that as heat and electricity, and perhaps magnetism, are known to displace air, that it is not impossible but that the increased or diminished quantities of these fluids diffused in the atmosphere may increase its weight a well as its bulk; since their specific attractions or affinities to matter are very strong, they probably also possess general gravitation to the earth; a subject which wants further investigation. See Note XXVI.

SOUTH-WEST WINDS.

The velocity of the surface of the earth in moving round its axis diminishes from the equator to the poles. Whence if a region of air in this country should be suddenly removed a few degrees towards the north it must constitute a western wind, because from the velocity it had previously acquired in this climate by its friction with the earth it would for a time move quicker than the surface of the country it was removed to; the contrary must ensue when a region of air is transported from this country a few degrees southward, because the velocity it had acquired in this climate would be less than that of the earth's surface where it was removed to, whence it would appear to constitute a wind from the east, while in reality the eminent parts of the earth would be carried against the too slow air. But if this transportation of air from south to north be performed gradually, the motion of the wind will blow in the diagonal between south and west. And on the contrary if a region of air be gradually removed from north to south it would also blow diagonally between the north and east, from whence we may safely conclude that all our winds in this country which blow from the north or east, or any point between them, consist of regions of air brought from the north; and that all our winds blowing from the south or west, or from any point between them, are regions of air brought from the south.

It frequently happens during the vernal months that after a north-east wind has passed over us for several weeks, during which time the barometer has stood at above 30½ inches, it becomes suddenly succeeded by a south-west wind, which also continues several weeks, and the barometer sinks to nearly 28½ inches. Now as two inches of the mercury in the barometer balance one-fifteenth part of the whole atmosphere, an important question here presents itself, *what is become of all this air.*

1. This great quantity of air can not be carried in a superior current towards the line, while the inferior current flows towards the poles, because then it would equally affect the barometer, which should not therefore subside from 30½ inches to 28½ for six weeks together.

2. It cannot be owing to the air having lost all the moisture which was previously dissolved in it, because these warm south-west winds are replete with moisture, and the cold north-east winds, which weigh up the mercury in the barometer to 31 inches, consist of dry air.

3. It can not be carried over the polar regions and be accumulated on the meridian opposite to us in its passage towards the line, as such an accumulation would equal one-fifteenth of the whole atmosphere, and can not be supposed to remain in that situation for six weeks together.

4. It can not depend on the exiſtence of tides in the atmoſphere, ſince it muſt then correſpond to lunar periods. Nor to accumulations of air from the ſpecific levity of the upper regions of the atmoſphere, ſince its degree of fluidity muſt correſpond with its tenuity, and conſequently ſuch great mountains of air can not be ſuppoſed to exiſt for ſo many weeks together as the ſouth weſt winds ſometimes continue.

5. It remains therefore that there muſt be at this time a great and ſudden abſorption of air in the polar circle by ſome unknown operation of nature, and that the ſouth wind runs in to ſupply the deficiency. Now as this ſouth wind conſiſts of air brought from a part of the earth's ſurface which moves faſter than it does in this climate it muſt have at the ſame time a direction from the weſt by retaining part of the velocity it had previouſly acquired. Theſe ſouth-weſt winds coming from a warmer country, and becoming colder by their contact with the earth of this climate, and by their expanſion, (ſo great a part of the ſuperincumbent atmoſphere having vaniſhed,) precipitate their moiſture; and as they continue for ſeveral weeks to be abſorbed in the polar circle would ſeem to receive a perpetual ſupply from the tropical regions, eſpecially over the line, as will hereafter be ſpoken of.

It may ſometimes happen that a north-eaſt wind having paſſed over us may be bent down and driven back before it has acquired any heat from the climate, and may thus for a few hours or a day have a ſouth-weſt direction, and from its deſcending from a higher region of the atmoſphere may poſſeſs a greater degree of cold than an inferior north eaſt current of air.

The extreme cold of Jan. 13, 1709, at Paris came on with a gentle ſouth wind, and was diminiſhed when the wind changed to the north, which is accounted for by Mr. Homberg from a reflux of air which had been flowing for ſome time from the north. Chemical Eſſays by R. Watſon, Vol. V. p. 182.

It may happen that a north-eaſt current may for a day or two paſs over us and produce inceſſant rain by mixing with the inferior ſouth-weſt current; but this as well as the former is of ſhort duration, as its friction will ſoon carry the inferior current along with it, and dry or froſty weather will then ſucceed.

NORTH-EAST WINDS.

The north eaſt-winds of this country conſiſt of regions of air from the north, travelling ſometimes at the rate of about a mile in two minutes during the vernal months for ſeveral weeks together from the polar regions toward the ſouth, the mercury in the barometer ſtanding above 30. Theſe winds conſiſt of air, greatly cooled by the evaporation of the ice and ſnow over which it paſſes, and as they become warmer by their contact with the earth of this climate are capable of diſſolving more moiſture as they paſs along, and are thence attended with froſts in winter and with dry hot weather in ſummer.

1. This great quantity of air can not be ſupplied by ſuperior currents paſſing in a contrary direction from ſouth to north, becauſe ſuch currents muſt as they ariſe into the atmoſphere a mile or two high become expoſed to ſo great cold as to occaſion them

to depoſit their moiſture, which would fall through the inferior current upon the earth in ſome part of their paſſage.

2. The whole atmoſphere muſt have increaſed in quantity, becauſe it appears by the barometer that there exiſts one-fifteenth part more air over us for many weeks together, which could not be thus accumulated by difference of temperature in reſpect to heat, or by any aeroſtatic laws at preſent known, or by any lunar influence.

From whence it would appear that immenſe maſſes of air were ſet at liberty from their combinations with ſolid bodies, along with a ſufficient quantity of combined heat, within the polar circle, or in ſome region to the north of us; and that they thus perpetually increaſe the quantity of the atmoſphere; and that this is again at certain times re-abſorbed, or enters into new combinations at the line or tropical regions. By which wonderful contrivance the atmoſphere is perpetually renewed and rendered fit for the ſupport of animal and vegetable life.

SOUTH-EAST WINDS.

The ſouth-eaſt winds of this country conſiſt of air from the north which had paſſed by us, or over us, and before it had obtained the velocity of the earth's ſurface in this climate had been driven back, owing to a deficiency of air now commencing at the polar regions. Hence theſe are generally dry or freezing winds, and if they ſucceed north-eaſt winds ſhould prognoſticate a change of wind from north-eaſt to ſouth-weſt; the barometer is generally about 30. They are ſometimes attended with cloudy weather, or rain, owing to their having acquired an increaſed degree of warmth and moiſture before they became retrograde; or to their being mixed with air from the ſouth.

2. Sometimes theſe ſouth-eaſt winds conſiſt of a vertical eddy of north-eaſt air, without any mixture of ſouth-weſt air; in that caſe the barometer continues above 30, and the weather is dry or froſty for four or five days together.

It ſhould here be obſerved, that air being an elaſtic fluid muſt be more liable to eddies than water, and that theſe eddies muſt extend into cylinders or vortexes of greater diameter, and that if a vertical eddy of north-eaſt air be of ſmall diameter or has paſſed but a little way to the ſouth of us before its return, it will not have gained the velocity of the earth's ſurface to the ſouth of us, and will in conſequence become a ſouth-eaſt wind.—But if the vertical eddy be of large diameter, or has paſſed much to the ſouth of us, it will have acquired velocity from its friction with the earth's ſurface to the ſouth of us, and will in conſequence on its return become a ſouth-weſt wind, producing great cold.

NORTH-WEST WINDS.

There ſeem to be three ſources of the north-weſt winds of this hemiſphere of the earth. 1. When a portion of ſouthern air, which was paſſing over us, is driven back by accumulation of new air in the polar regions. In this caſe I ſuppoſe they are generally moiſt or rainy winds, with the barometer under 30, and if the wind had previouſly been in the ſouth-weſt, it would ſeem to prognoſticate a change to the north-eaſt.

2. If a current of north wind is passing over us but a few miles high, without any easterly direction; and is bent down upon us, it must immediately possess a westerly direction, because it will now move faster than the surface of the earth where it arrives; and thus becomes changed from a north-east to a north-west wind. This descent of a north-east current of air producing a north-west wind may continue some days with clear or freezing weather, as it may be simply owing to a vertical eddy of north-east air, as will be spoken of below. It may otherwise be forced down by a current of south-west wind passing over it, and in this case it will be attended with rain for a few days by the mixture of the two airs of different degrees of heat; and will prognosticate a change of wind from north-east to south-west if the wind was previously in the north-east quarter.

3. On the eastern coast of North America the north-west winds bring frost, as the north-east winds do in this country, as appears from variety of testimony. This seems to happen from a vertical spiral eddy made in the atmosphere between the shore and the ridge of mountains which form the spine or back-bone of that continent. If a current of water runs along the hypothenuse of a triangle an eddy will be made in the included angle, which will turn round like a water-wheel as the stream passes in contact with one edge of it. The same must happen when a sheet of air flowing along from the north-east rises from the shore in a straight line to the summit of the Apalachian mountains, a part of the stream of north-east air will flow over the mountains, another part will revert and circulate spirally between the summit of the country and the eastern shore, continuing to move toward the south; and thus be changed from a north-east to a north-west wind.

This vertical spiral eddy having been in contact with the cold summits of these mountains, and descending from higher parts of the atmosphere will lose part of its heat, and thus constitute one cause of the greater coldness of the eastern sides of North America than of the European shores opposite to them, which is said to be equal to twelve degrees of north latitude, which is a wouderful fact, not otherwise easy to be explained, since the heat of the springs at Philadelphia is said to be 52, which is greater than the medium heat of the earth in this country.

The existence of vertical eddies, or great cylinders of air rolling on the surface of the earth, is agreeable to the observations of the constructors of windmills; who on this idea place the area of the sails leaning backwards, inclined to the horizon; and believe that then they have greater power than when they are placed quite perpendicularly. The same kind of rolling cylinders of water obtain in rivers owing to the friction of the water against the earth at their bottoms; as is known by bodies having been observed to float upon their surfaces quicker than when immersed to a certain depth. These vertical eddies of air probably exist all over the earth's surface, but particularly at the bottom or sides of mountains; and more so probably in the course of the south-west than of the north-east winds; because the former fall from an eminence, as it were, on a part of the earth where there is a deficiency of the quantity of air; as is shewn by the sinking of the barometer: whereas the latter are pushed or

squeezed forward by an addition to the atmosphere behind them, as appears by the rising of the barometer.

TRADE-WINDS.

A column of heated air becomes lighter than before, and will therefore ascend, by the pressure of the cold air which surrounds it, like a cork in water, or like heated smoke in a chimney.

Now as the sun passes twice over the equator for once over either tropic, the equator has not time to become cool; and on this account it is in general hotter at the line than at the tropics; and therefore the air over the line, except in some few instances hereafter to be mentioned, continues to ascend at all seasons of the year, pressed upwards by regions of air brought from the tropics.

This air thus brought from the tropics to the equator, would constitute a north wind on one side of the equator, and a south wind on the other; but as the surface of the earth at the equator moves quicker than the surface of the earth at the tropics, it is evident that a region of air brought from either tropic to the equator, and which had previously only acquired the velocity of the earth's surface at the tropics, will now move too slow for the earth's surface at the equator, and will thence appear to move in a direction contrary to the motion of the earth. Hence the trade-winds, though they consist of regions of air brought from the north on one side of the line, and from the south on the other, will appear to have the diagonal direction of north-east and south-west winds.

Now it is commonly believed that there are superior currents of air passing over these north-east and south-west currents in a contrary direction, and which descending near the tropics produce vertical whirlpools of air. An important question here again presents itself, *What becomes of the moisture which this heated air ought to deposit, as it cools in the upper regions of the atmosphere in its journey to the tropics?* It has been shewn by Dr. Priestley and Mr. Ingenhouz that the green matter at the bottom of cisterns, and the fresh leaves of plants immersed in water, give out considerable quantities of vital air in the sun-shine; that is, the perspirable matter of plants (which is water much divided in its egress from their minute pores) becomes decomposed by the sun's light, and converted into two kinds of air, the vital and inflammable airs. The moisture contained or dissolved in the ascending heated air at the line must exist in great tenuity; and by being exposed to the great light of the sun in that climate, the water may be decomposed, and the new airs spread on the atmosphere from the line to the poles.

1. From there being no constant deposition of rains in the usual course of the trade-winds, it would appear that the water rising at the line is decomposed in its ascent.

2. From the observations of M. Bougner on the mountain Pinchinca, one of the Cordelieres immediately under the line, there appears to be no condensible vapour above three or four miles high. Now though the atmosphere at that height may be cold to a very considerable degree; yet its total deprivation of condensible vapour would seem to shew, that its water was decomposed; as there are no experiments to evince that any degree of cold hitherto known has been able to deprive air of its moisture; and great

abundance of ſnow is depoſited from the air that flows to the polar regions, though it is expoſed to no greater degrees of cold in its journey thither than probably exiſts at four miles height in the atmoſphere at the line.

3. The hygrometer of Mr. Sauſſure alſo pointed to dryneſs as he aſcended into rarer air; the ſingle hair of which it was conſtructed, contracting from deficiency of moiſture. Eſſais ſur l'Hygromet. p. 143.

From theſe obſervations it appears either that rare and cold air requires more moiſture to ſaturate it than denſe air; or that the moiſture becomes decompoſed and converted into air, as it aſcends into theſe cold and rare regions of the atmoſphere.

4. There ſeems ſome analogy between the circumſtance of air being produced or generated in the cold parts of the atmoſphere both at the line and at the poles.

MONSOONS AND TORNADOES.

1. In the Arabian and Indian ſeas are winds, which blow ſix months one way, and ſix months the other, and are called Monſoons; by the accidental diſpoſitions of land and ſea it happens, that in ſome places the air near the tropic is ſuppoſed to become warmer when the ſun is vertical over it, than at the line. The air in theſe places conſequently aſcends preſſed upon one ſide by the north-eaſt regions of air, and on the other ſide by the ſouth-weſt regions of air. For as the air brought from the ſouth has previouſly obtained the velocity of the earth's ſurface at the line, it moves faſter than the earth's ſurface near the tropic where it now arrives, and becomes a ſouth-weſt wind, while the air from the north becomes a north-eaſt wind as before explained. Theſe two winds do not ſo quietly join and aſcend as the north-eaſt and ſouth-eaſt winds, which meet at the line with equal warmth and velocity and form the trade-winds; but as they meet in contrary directions before they aſcend, and cannot be ſuppoſed accurately to balance each other, a rotatory motion will be produced as they aſcend like water falling through a hole, and an horizontal or ſpiral eddy is the conſequence; theſe eddies are more or leſs rapid, and are called Tornadoes in their moſt violent ſtate, raiſing water from the ocean in the weſt or ſand from the deſerts of the eaſt, in leſs violent degrees they only mix together the two currents of north-eaſt and ſouth-weſt air, and produce by this means inceſſant rains, as the air of the north-eaſt acquires ſome of the heat from the ſouth-weſt wind, as explained in Note XXV. This circumſtance of the eddies produced by the monſoon-winds was ſeen by Mr. Bruce in Abyſſinia; he relates that for many ſucceſſive mornings at the commencement of the rainy monſoon, he obſerved a cloud of apparently ſmall dimenſions whirling round with great rapidity, and in a few minutes the heavens became covered with dark clouds with conſequent great rains. See Note on Canto III. l. 125.

2. But it is not only at the place where the air aſcends at the northern extremity of the rainy monſoon, and where it forms tornadoes, as obſerved above by Mr. Bruce, but over a great tract of country ſeveral degrees in length in certain parts as in the Arabian ſea, a perpetual rain for ſeveral months deſcends, ſimilar to what happens for weeks together in our own climate in a leſs degree during the ſouth-weſt winds. Another im-

portant queſtion preſents itſelf here, *if the climate to which this ſouth-weſt wind arrives, is not colder than that it comes from, why ſhould it depoſit its moiſture during its whole journey? if it be a colder climate, why does it come thither?* The tornadoes of air above deſcribed can extend but a little way, and it is not eaſy to conceive that a ſuperior cold current of air can mix with an inferior one, and thus produce ſhowers over ten degrees of country, ſince at about three miles high there is perpetual froſt; and what can induce theſe narrow and ſhallow currents to flow over each other ſo many hundred miles?

Though the earth at the northren extremity of this monſoon may be more heated by certain circumſtances of ſituation than at the line, yet it ſeems probable that the intermediate country between that and the line, may continue colder than the line (as in other parts of the earth) and hence that the air coming from the line to ſupply this aſcent or deſtruction of air at the northern extremity of the monſoon will be cooled all the way in its approach, and in conſequence depoſit its water. It ſeems probable that at the northern extremity of this monſoon, where the tornadoes or hurricanes exiſt, that the air not only aſcends but is in part converted into water, or otherwiſe diminiſhed in quantity, as no account is given of the exiſtence of any ſuperior currents of it.

As the ſouth-weſt winds are always attended with a light atmoſphere, an incipient vacancy, or a great diminution of air muſt have taken place to the northward of them in all parts of the earth wherever they exiſt, and a depoſition of their moiſture ſucceeds their being cooled by the climate they arrive at, and not by a contrary current of cold air over them, ſince in that caſe the barometer would not ſink. They may thus in our own country be termed monſoons without very regular periods.

3. Another cauſe of TORNADOES independent of the monſoons is ingeniouſly explained by Dr. Franklin, when in the tropical countries a ſtratum of inferior air becomes ſo heated by its contact with the warm earth, that its expanſion is increaſed more than is equivalent to the preſſure of the ſtratum of air over it; or when the ſuperior ſtratum becomes more condenſed by cold than the inferior one by preſſure, the upper region will deſcend and the lower one aſcend. In this ſituation if one part of the atmoſphere be hotter from ſome fortuitous circumſtances, or, has leſs preſſure over it, the lower ſtratum will begin to aſcend at this part, and reſemble water falling through a hole as mentioned above. If the lower region of air was going forwards with conſiderable velocity, it will gain an eddy by riſing up this hole in the incumbent heavy air, ſo that the whirlpool or tornado has not only its progreſſive velocity, but its circular one alſo, which thus lifts up or overturns every thing within its ſpiral whirl. By the weaker whirlwinds in this country the trees are ſometimes thrown down in a line of only twenty or forty yards in breadth, making a kind of avenue through a country. In the Weſt Indies the ſea riſes like a cone in the whirl, and is met by black clouds produced by the cold upper air and the warm lower air being rapidly mixed; whence are produced the great and ſudden rains called water-ſpouts; while the upper and lower airs exchange their plus or minus electricity in perpetual lightenings.

LAND AND SEA-BREEZES.

The fea being a tranfparent mafs is lefs heated at its furface by the fun's rays than the land, and its continual change of furface contributes to preferve a greater uniformity in the heat of the air which hangs over it. Hence the furface of the tropical iflands is more heated during the day than the fea that furrounds them, and cools more in the night by its greater elevation: whence in the afternoon when the lands of the tropical iflands have been much heated by the fun, the air over them afcends preffed upwards by the cooler air of the incircling ocean, in the morning again the land becoming cooled more than the fea, the air over it defcends by its increafed gravity, and blows over the ocean near its fhores.

CONCLUSION.

1. There are various irregular winds befides thofe above defcribed, which confift of horizontal or vertical eddies of air owing to the inequality of the earth's furface, or the juxtapofition of the fea. Other irregular winds have their origin from increafed evaporation of water, or its fudden devaporation and defcent in fhowers; others from the partial expanfion and condenfation of air by heat and cold; by the accumulation or defect of electric fluid, or to the air's new production or abforption occafioned by local caufes not yet difcovered. See Notes VII. and XXV.

2. There feem to exift only two original winds: one confifting of air brought from the north, and the other of air brought from the fouth. The former of thefe winds has alfo generally an apparent direction from the eaft, and the latter from the weft, arifing from the different velocities of the earth's furface. All the other winds above defcribed are deflections or retrogreffions of fome parts of thefe currents of air from the north or fouth.

3. One fifteenth part of the atmofphere is occafionally deftroyed, and occafionally reproduced by unknown caufes. Thefe caufes are brought into immediate activity over a great part of the furface of the earth at nearly the fame time, but always act more powerful to the northward than to the fouthward of any given place; and would hence feem to have their principal effect in the polar circles, exifting neverthelefs though with lefs power toward the tropics or at the line.

For when the north-eaft wind blows the barometer rifes, fometimes from 28½ inches to 30½, which fhews a great new generation of air in the north; and when the fouth-weft wind blows the barometer finks as much, which fhews a great deftruction of air in the north. But as the north-eaft winds fometimes continue for five or fix weeks, the newly-generated air muft be deftroyed at thofe times in the warmer climates to the fouth of us, or circulate in fuperior currents, which has been fhewn to be improbable from its not depofiting its water. And as the fouth-weft winds fometimes continue for fome weeks, there muft be a generation of air to the fouth at thofe times, or fuperior currents, which laft has been fhewn to be improbable.

4. The north-eaft winds being generated about the poles are pufhed forwards towards the tropics or line, by the preffure from behind, and hence they become warmer, as

explained in Note VII. as well as by their coming into contact with a warmer part of the earth which contributes to make these winds greedily absorb moisture in their passage. On the contrary, the south-west winds, as the atmosphere is suddenly diminished in the polar regions, are drawn as it were into an incipient vacancy, and become therefore expanded in their passage, and thus generate cold, as explained in Note VII. and are thus induced to part with their moisture, as well as by their contact with a colder part of the earth's surface. Add to this, that the difference in the sound of the north-east and south-west winds may depend on the former being pushed forwards by a pressure behind, and the latter falling as it were into a partial or incipient vacancy before; whence the former becomes more condensed, and the latter more rarefied as it passes. There is a whistle, termed a lark-call, which consists of a hollow cylinder of tin-plate, closed at each end, about half an inch in diameter and a quarter of an inch high, with opposite holes about the size of a goose-quill through the centre of each end; if this lark-whistle be held between the lips the sound of it is manifestly different when the breath is forceably blown through it from within outwards, and when it is sucked from without inwards. Perhaps this might be worthy the attention of organ-builders.

5. A stop is put to this new generation of air, when about a fifteenth of the whole is produced, by its increasing pressure; and a similar boundary is fixed to its absorption or destruction by the decrease of atmospheric pressure. As water requires more heat to convert it into vapour under a heavy atmosphere than under a light one, so in letting off the water from muddy fish-ponds great quantities of air-bubbles are seen to ascend from the bottom, which were previously confined there by the pressure of the water. Similar bubbles of inflammable air are seen to arise from lakes in many seasons of the year, when the atmosphere suddenly becomes light.

6. The increased absorptions and evolutions of air must, like its simple expansions, depend much on the presence or absence of heat and light, and will hence, in respect to the times and places of its production and destruction, be governed by the approach or retrocession of the sun, and on the temperature, in regard to heat, of various latitudes, and parts of the same latitude, so well explained by Mr. Kirwan.

7. Though the immediate cause of the destruction or reproduction of great masses of air at certain times, when the wind changes from north to south, or from south to north can not yet be ascertained; yet as there appears greater difficulty in accounting for this change of wind for any other known causes, we may still suspect that there exists in the arctic and antarctic circles a BEAR or DRAGON yet unknown to philosophers, which at times suddenly drinks up, and as suddenly at other times vomits out one-fifteenth part of the atmosphere: and hope that this or some future age will learn how to govern and domesticate a monster which might be rendered of such important service to mankind.

INSTRUMENTS.

IF along with the usual registers of the weather observations were made on the winds in many parts of the earth with the three following instruments, which might be constructed at no great expence, some useful information might be acquired.

1. To mark the hour when the wind changes from north-caſt to ſouth-weſt, and the contrary. This might be managed by making a communication from the vane of a weathercock to a clock; in ſuch a manner, that if the vane ſhould revolve quite round, a tooth on its revolving axis ſhould ſtop the clock, or put back a ſmall bolt on the edge of a wheel revolving once in twenty-four hours.

2. To diſcover whether in a year more air paſſed from north to ſouth, or the contrary. This might be effected by placing a windmill-ſail of copper about nine inches diameter in a hollow cylinder about ſix inches long, open at both ends, and fixed on an eminent ſituation exactly north and ſouth. Thence only a part of the north-eaſt and ſouth-weſt currents would affect the ſail ſo as to turn it; and if its revolutions were counted by an adapted machinery, as the ſail would turn one way with the north currents of air, and the contrary one with the ſouth currents, the advance of the counting finger either way would ſhew which wind had prevailed moſt at the end of the year.

3. To diſcover the rolling cylinders of air, the vane of a weathercock might be ſo ſuſpended as to dip or riſe vertically, as well as to have its horizontal rotation.

RECAPITULATION.

NORTH-EAST WINDS conſiſt of air flowing from the north, where it ſeems to be occaſionally produced; has an apparent direction from the eaſt owing to its not having acquired in its journey the increaſing velocity of the earth's ſurface; theſe winds are analogous to the trade-winds between the tropics, and frequently continue in the vernal months for four and ſix weeks together, with a high barometer, and fair or froſty weather. 2. They ſometimes conſiſt of ſouth-weſt air, which had paſſed by us or over us, driven back by a new accumulation of air in the north. Theſe continue but a day or two, and are attended with rain. See Note XXV.

SOUTH-WEST WIND conſiſts of air flowing from the ſouth, and ſeems occaſionally abſorbed at its arrival to the more northern latitudes. It has a real direction from the weſt owing to its not having loſt in its journey the greater velocity it had acquired from the earth's ſurface from whence it came. Theſe winds are analogous to the monſoons between the tropics, and frequently continue for four or ſix weeks together, with a low barometer and rainy weather. 2. They ſometimes conſiſt of north-eaſt air, which had paſſed by us or over us, which becomes retrograde by a commencing deficiency of air in the north. Theſe winds continue but a day or two, attended with ſeverer froſt with a ſinking barometer; their cold being increaſed by their expanſion, as they return, into an incipient vacancy.

NORTH-WEST WINDS conſiſt, firſt, of ſouth-weſt winds, which have paſſed over us, bent down and driven back towards the ſouth by newly generated northern air. They continue but a day or two, and are attended with rain or clouds. 2. They conſiſt of north-eaſt winds bent down from the higher parts of the atmoſphere, and having there acquired a greater velocity than the earth's ſurface; are froſty or fair. 3. They conſiſt of north-eaſt winds formed into a vertical ſpiral eddy, as on the eaſtern coaſts of North America, and bring ſevere froſt.

SOUTH-EAST WINDS consist, first, of north-east winds become retrograde, continue for a day or two, frosty or fair, sinking barometer. 2. They consist of north-east winds formed into a vertical eddy not a spiral one, frost or fair.

NORTH WINDS consist, first, of air flowing slowly from the north, so that they acquire the velocity of the earth's surface as they approach, are fair or frosty, seldom occur. 2. They consist of retrograde south winds; these continue but a day or two, are preceded by south-west winds; and are generally succeeded by north-east winds, cloudy or rainy, barometer rising.

SOUTH WINDS consist, first, of air flowing slowly from the south, loosing their previous western velocity by the friction of the earth's surface as they approach, moist, seldom occur. 2. They consist of retrograde north winds; these continue but a day or two, are preceded by north-east winds, and generally succeeded by south-west winds, colder, barometer sinking.

EAST WINDS consist of air brought hastily from the north, and not impelled farther southward, owing to a sudden beginning absorption of air in the northern regions, very cold, barometer high, generally succeeded by south-west wind.

WEST WINDS consist of air brought hastily from the south, and checked from proceeding further to the north by a beginning production of air in the northern regions, warm and moist, generally succeeded by north-east wind. 2. They consist of air bent down from the higher regions of the atmosphere, if this air be from the south, and brought hastily it becomes a wind of great velocity, moving perhaps 60 miles an hour, is warm and rainy; if it consists of northern air bent down it is of less velocity and colder.

Application of the preceding Theory to some Extracts from a Journal of the Weather.

Dec. 1, 1790. The barometer sunk suddenly, and the wind, which had been some days north-east with frost, changed to south-east with an incessant though moderate fall of snow. A part of the northern air, which had passed by us I suppose, now became retrograde before it had acquired the velocity of the earth's surface to the south of us, and being attended by some of the southern air in its journey, the moisture of the latter became condensed and frozen by its mixture mith the former.

Dec. 2, 3. The wind changed to north-west and thawed the snow. A part of the southern air, which had passed by us or over us, with the retrograde northern air above described, was now in its turn driven back, before it had lost the velocity of the surface of the earth to the south of us, and consequently became a north-west wind; and not having lost the warmth it brought from the south produced a thaw.

Dec. 4, 5. Wind changed to north-east with frost and a rising barometer. The air from the north continuing to blow, after it had driven back the southern air as above described, became a north-east wind, having less velocity than the surface of the earth in this climate, and produced frost from its coldness.

Dec. 6, 7. Wind now changed to the ſouth-weſt with inceſſant rain and a ſinking barometer. From unknown cauſes I ſuppoſe the quantity of air to be diminiſhed in the polar regions, and the ſouthern air cooled by the earth's ſurface, which was previouſly frozen, depoſits its moiſture for a day or two; afterwards the wind continued ſouth-weſt without rain, as the ſurface of the earth became warmer.

March 18, 1785. There has been a long froſt; a few days ago the barometer ſunk to 29½, and the froſt became more ſevere. Becauſe the air being expanded by a part of the preſſure being taken off became colder. This day the mercury roſe to 30, and the froſt ceaſed, the wind continuing as before between north and eaſt. *March* 19. Mercury above 30, weather ſtill milder, no froſt, wind north-eaſt. *March* 20. The ſame, for the mercury riſing ſhews that the air becomes more compreſſed by the weight above. and in conſequence gives out warmth.

April 4, 5. Froſt, wind north-eaſt, the wind changed in the middle of the day to the north-weſt without rain, and has done ſo for three or four days, becoming again north-eaſt at night. For the ſun now giving greater degrees of heat, the air aſcends as the ſun paſſes the zenith, and is ſupplied below by the air on the weſtern ſide as well as on the eaſtern ſide of the zenith during the hot part of the day; whence for a few hours, on the approach of the hot part of the day, the air acquires a weſterly direction in this longitude. If the north-weſt wind had been cauſed by a retrograde motion of ſome ſouthern air, which had paſſed over us, it would have been attended with rain or clouds.

April 10. It rained all day yeſterday, the wind north-weſt, this morning there was a ſharp froſt. The evaporation of the moiſture, (which fell yeſterday) occaſioned by the continuance of the wind, produced ſo much cold as to freeze the dew.

May 12. Frequent ſhowers with a current of colder wind preceding every ſhower. The ſinking of the rain or cloud preſſed away the air from beneath it in its deſcent, which having been for a time ſhaded from the ſun by the floating cloud, became cooled in ſome degree.

June 20. The barometer ſunk, the wind became ſouth-weſt, and the whole heaven was inſtantly covered with clouds. A part of the incumbent atmoſphere having vaniſhed, as appeared by the ſinking of the barometer, the remainder became expanded by its elaſticity, and thence attracted ſome of the matter of heat from the vapour intermixed with it, and thus in a few minutes a total devaporation took place, as in exhauſting the receiver of an air-pump. See note XXV. At the place where the air is deſtroyed, currents both from the north and ſouth flow in to ſupply the deficiency, (for it has been ſhewn that there are no other proper winds but theſe two) and the mixture of theſe winds produces ſo ſudden condenſation of the moiſture, both by the coldneſs of the northern air and the expanſion of both of them, that lightning is given out, and an incipient tornado takes place; whence thunder is ſaid frequently to approach againſt the wind.

Auguſt 28, 1732. Barometer was at 31, and *Dec.* 30, in the ſame year, it was at 28 2-tenths. Medical Eſſays, Edinburgh, Vol. II. p. 7. It appears from theſe journals that the mercury at Edinburgh varies ſometimes nearly three inches. or one tenth of

the whole atmoſphere. From the journals kept by the Royal Society at London it appears ſeldom to vary more than two inches, or one-fifteenth of the whole atmoſphere. The quantity of the variation is ſaid ſtill to decreaſe nearer the line, and to increaſe in the more northern latitudes; which much confirms the idea that there exiſts at certain times a great deſtruction or production of air within the polar circle.

July 2, 1732. The weſterly winds in the journal in the Medical Eſſays, Vol. II. above referred to, are frequently marked with the number three to ſhew their greater velocity, whereas the eaſterly winds ſeldom approach to the number two. The greater velocity of the weſterly winds than the eaſterly ones is well known I believe in every climate of the world; which may be thus explained from the theory above delivered. 1. When the air is ſtill, the higher parts of the atmoſphere move quicker than thoſe parts which touch the earth, becauſe they are at a greater diſtance from the axis of motion. 2. The part of the atmoſphere where the north or ſouth wind comes from is higher than the part of it where it comes to, hence the more elevated parts of the atmoſphere continue to deſcend towards the earth as either of thoſe winds approach. 3. When ſouthern air is brought to us it poſſeſſes a weſterly direction alſo, owing to the velocity it had previouſly acquired from the earth's ſurface; and if it conſiſts of air from the higher parts of the atmoſphere deſcending nearer the earth, this weſterly velocity becomes increaſed. But when northern air is brought to us, it poſſeſſes an apparent eaſterly direction alſo, owing to the velocity which it had previouſly acquired from the earth's ſurface being leſs than that of the earth's ſurface in this latitude; now if the north-eaſt wind conſiſts of air deſcending from higher parts of the atmoſphere, this deficiency of velocity will be leſs, in conſequence of the ſame cauſe, viz. The higher parts of the atmoſphere deſcending, as the wind approaches, increaſes the real velocity of the weſtern winds, and decreaſes the apparent velocity of the eaſtern ones.

October 22. Wind changed from ſouth-eaſt to ſouth-weſt. There is a popular prognoſtication that if the wind changes from the north towards the ſouth paſſing through the eaſt, it is more likely to continue in the ſouth, than if it paſſes through the weſt, which may be thus accounted for. If the north-eaſt wind changes to a north-weſt wind, it ſhews either that a part of the northern air deſcends upon us in a ſpiral eddy, or that a ſuperior current of ſouthern air is driven back; but if a north-eaſt wind be changed into a ſouth-eaſt wind it ſhews that the northern air is become retrograde, and that in a day or two, as ſoon as that part of it has paſſed, which has not gained the velocity of the earth's ſurface in this latitude, it will become a ſouth wind for a few hours, and then a ſouth-weſt wind.

The writer of this imperfect ſketch of anemology wiſhes it may incite ſome perſon of greater leizure and ability to attend to this ſubject, and by comparing the various meteorological journals and obſervations already publiſhed, to conſtruct a more accurate and methodical treatiſe on this intereſting branch of philoſophy.

NOTE XXXIV.——VEGETABLE PERSPIRATION.

And wed the enamoured Oxygene to Light. CANTO IV. l. 34.

WHEN points or hairs are put into ſpring-water, as in the experiments of Sir B. Thompſon, (Philoſ. Tranſ. Vol. LXXVII.) and expoſed to the light of the ſun, much air, which looſely adhered to the water, riſes in bubbles, as explained in note on Fucus, Vol. II. A ſtill greater quantity of air, and of a purer kind, is emitted by Dr. Prieſtley's green matter, and by vegetable leaves growing in water in the ſun-ſhine, according to Mr. Ingenhouze's experiments; both which I ſuſpect to be owing to a decompoſition of the water perſpired by the plant, for the edge of a capillary tube of great tenuity may be conſidered as a circle of points, and as the oxygene, or principle of vital air, may be expanded into a gas by the ſun's light; the hydrogene or inflammable air may be detained in the pores of the vegetable.

Hence plants growing in the ſhade are white, and become green by being expoſed to the ſun's light: for their natural colour being blue, the addition of hydrogene adds yellow to this blue, and *tans* them green. I ſuppoſe a ſimilar circumſtance takes place in animal bodies; their perſpirable matter as it eſcapes in the ſun-ſhine becomes decompoſed by the edges of their pores as in vegetables, though in leſs quantity, as their perſpiration is leſs, and by the hydrogene being retained the ſkin becomes *tanned* yellow. In proof of this it muſt be obſerved that both vegetable and animal ſubſtances become bleached white by the ſun-beams when they are dead, as cabbage-ſtalks, bones, ivory, tallow, bees-wax, linen and cotton cloth; and hence I ſuppoſe the copper-coloured natives of ſunny countries might become etiolated or blanched by being kept from their infancy in the dark, or removed for a few generations to more northerly climates.

It is probable that on a ſunny morning much pure air becomes ſeparated from the dew by means of the points of vegetables on which it adheres, and much inflammable air imbibed by the vegetable, or combined with it; and by the ſun's light thus decompoſing water the effects of it in bleaching linen ſeems to depend (as deſcribed in Note X.): the water is decompoſed by the light at the ends or points of the cotton or thread, and the vital air unites with the phlogiſtic or colouring matters of the cloth, and produces a new acid, which is either itſelf colourleſs or waſhes out, at the ſame time the inflammable part of the water eſcapes. Hence there ſeems a reaſon why cotton bleaches ſo much ſooner than linen, viz. becauſe its fibres are three or four times ſhorter, and therefore protrude ſo many more points, which ſeem to facilitate the liberation of the vital air from the inflammable part of the water.

Bee's wax becomes bleached by expoſure to the ſun and dews in a ſimilar manner as metals become calcined or ruſty, viz. by the water on their ſurface being decompoſed; and hence the inflammable material which cauſed the colour becomes united with vital air forming a new acid, and is waſhed away.

Oil close ſtopped in a phial not full, and expoſed long to the ſun's light, becomes bleached, as I ſuppoſe, by the decompoſition of the water it contains; the inflammable air riſing above the ſurface, and the vital air uniting with the colouring matter of the oil. For it is remarkable, that by ſhutting up a phial of bleached oil in a dark drawer, it in a little time becomes coloured again.

The following experiment ſhews the power of light in ſeparating vital air from another baſis, viz. from azote. Mr. Scheel inverted a glaſs veſſel filled with colourleſs nitrous acid into another glaſs containing the ſame acid, and on expoſing them to the ſun's light, the inverted glaſs became partly filled with pure air, and the acid at the ſame time became coloured. Scheel in Crell's Annal. 1786. But if the veſſel of colourleſs nitrous acid be quite full and ſtopped, ſo that no ſpace is left for the air produced to expand itſelf into, no change of colour takes place. Prieſtley's Exp. VI. p. 344. See Keir's very excellent Chemical Dictionary, p. 99. new edition.

A ſun-flower three feet and half high according to the experiment of Dr. Hales, perſpired two pints in one day (Vegetable Statics.) which is many times as much in proportion to its ſurface, as is perſpired from the ſurface and lungs of animal bodies; it follows that the vital air liberated from the ſurfaces of plants by the ſunſhine muſt much exceed the quantity of it abſorbed by their reſpiration, and that hence they improve the air in which they live during the light part of the day, and thus blanched vegetables will ſooner become *tanned into green* by the ſun's light, than etiolated animal bodies will become *tanned yellow* by the ſame means.

It is hence evident, that the curious diſcovery of Dr. Prieſtley, that his green vegetable matter and other aquatic plants gave out vital air when the ſun ſhone upon them, and the leaves of other plants did the ſame when immerſed in water, as obſerved by Mr. Ingenhouze, refer to the perſpiration of vegetables not to their reſpiration. Becauſe Dr. Prieſtley obſerved the pure air to come from both ſides of the leaves and even from the ſtalks of a water-flag, whereas one ſide of the leaf only ſerves the office of lungs, and certainly not the ſtalks. Exper. on Air, Vol. III. And thus in reſpect to the circumſtance, in which plants and animals ſeemed the furthereſt removed from each other, I mean in their ſuppoſed mode of reſpiration, by which one was believed to purify the air which the other had injured, they ſeem to differ only in degree, and the analogy between them remains unbroken.

Plants are ſaid by many writers to grow much faſter in the night than in the day; as is particularly obſervable in ſeedlings at their riſing out of the ground. This probably is a conſequence of their ſleep rather than of the abſence of light; and in this I ſuppoſe they alſo reſemble animal bodies.

NOTE XXXV.——VEGETABLE PLACENTATION.

While in bright veins the silvery sap ascends. CANTO IV. l. 419.

AS buds are the viviparous offspring of vegetables, it becomes necessary that they should be furnished with placental vessels for their nourishment, till they acquire lungs or leaves for the purpose of elaborating the common juices of the earth into nutriment. These vessels exist in bulbs and in seeds, and supply the young plant with a sweet juice till it acquires leaves, as is seen in converting barley into malt, and appears from the sweet taste of onions and potatoes, when they begin to grow.

The placental vessels belonging to the buds of trees are placed about the roots of most, as the vine; so many roots are furnished with sweet or mealy matter as fern-root, bryony, carrot, turnip, potatoe, or in the alburnum or sap-wood as in those trees which produce manna, which is deposited about the month of August, or in the joints of sugar cane, and grasses; early in the spring the absorbent mouths of these vessels drink up moisture from the earth, with a saccharine matter lodged for that purpose during the preceding autumn, and push this nutritive fluid up the vessels of the alburnum to every individual bud, as is evinced by the experiments of Dr. Hales, and of Mr. Walker in the Edinburgh Philosophical Transact. The former observed that the sap from the stump of a vine, which he had cut off in the beginning of April, arose twenty-one feet high in tubes affixed to it for that purpose, but in a few weeks it ceased to bleed at all, and Dr. Walker marked the progress of the ascending sap, and found likewise that as soon as the leaves became expanded the sap ceased to rise; the ascending juice of some trees is so copious and so sweet during the sap-season that it is used to make wine, as the birch, betula, and sycamore, acer pseudo-platinus, and particularly the palm.

During this ascent of the sap-juice each individual leaf-bud expands its new leaves, and shoots down new roots, covering by their intertexture the old bark with a new one; and as soon as these new roots (or bark) are capable of absorbing sufficient juices from the earth for the support of each bud, and the new leaves are capable of performing their office of exposing these juices to the influence of the air; the placental vessels cease to act, coalesce, and are transformed from sap-wood, or alburnum, into inert wood; serving only for the support of the new tree, which grows over them.

Thus from the pith of the new bud of the horse-chesnut five vessels pass out through the circle of the placental vessels above described, and carry with them a minuter circle of those vessels; these five bundles of vessels unite after their exit, and form the foot-stalk or petiole of the new five-fingered leaf, to be spoken of hereafter. This structure is well seen by cutting off a leaf of the horse-chesnut (Æsculus Hippocastanum) in September before it falls, as the buds of this tree are so large that the flower may be seen in them with the naked eye.

After a time, perhaps about midfummer, another bundle of veffels paffes from the pith through the alburnum or fap-veffels in the bofom of each leaf, and unites by the new bark with the leaf, which becomes either a flower-bud or a leaf-bud to be expanded in the enfuing fpring, for which purpofe an apparatus of placental veffels are produced with proper nutriment during the progrefs of the fummer and autumn, and thus the vegetable becomes annually increafed, ten thoufand buds often exifting on one tree, according to the eftimate of Linneus. Phil. Bot.

The vafcular connection of vegetable buds with the leaves in whofe bofoms they are formed is confirmed by the following experiment, (Oct. 20, 1781.) On the extremity of a young bud of the Mimofa (fenfitive plant) a fmall drop of acid of vitriol was put by means of a pen, and, after a few feconds, the leaf in whofe axilla it dwelt clofed and opened no more, though the drop of vitriolic acid was fo fmall as apparently only to injure the fummit of the bud. Does not this feem to fhew that the leaf and its bud have connecting veffels though they arife at different times and from different parts of the medulla or pith? And, as it exifts previoufly to it, that the leaf is the parent of the bud?

This placentation of vegetable buds is clearly evinced from the fweetnefs of the rifing fap, and from its ceafing to rife as foon as the leaves are expanded, and thus compleats the analogy between buds and bulbs. Nor need we wonder at the length of the umbilical cords of buds fince that muft correfpond with their fituation on the tree, in the fame manner as their lymphatics and arteries are proportionally elongated.

It does not appear probable that any umbilical artery attends thefe placental abforbents, fince, as there feems to be no fyftem of veins in vegetables to bring back the blood from the extremities of their arteries, (except their pulmonary veins,) there could not be any vegetable fluids to be returned to their placenta, which in vegetables feems to be fimply an organ for nutrition, whereas the placenta of the animal fœtus feems likewife to ferve as a refpiratory organ like the gills of fifhes.

NOTE XXXVI.——VEGETABLE CIRCULATION.

And refluent blood in milky eddies bends. CANTO IV. l. 420.

THE individuality of vegetable buds was ſpoken of before, and is confirmed by the method of raiſing all kinds of trees by Mr. Barnes. (Method of propagating Fruit Trees. 1759. Lond. Baldwin.) He cut a branch into as many pieces as there were buds or leaves upon it, and wiping the two wounded ends dry he quickly applied to each a cement, previouſly warmed a little, which conſiſted principally of pitch, and planted them in the earth. The uſe of this cement I ſuppoſe to conſiſt in its preventing the bud from bleeding to death, though the author aſcribes it to its antiſceptic quality.

Theſe buds of plants, which are thus each an individual vegetable, in many circumſtances reſemble individual animals, but as animal bodies are detached from the earth, and move from place to place in ſearch of food, and take that food at conſiderable intervals of time, and prepare it for their nouriſhment within their own bodies after it is taken, it is evident they muſt require many organs and powers which are not neceſſary to a ſtationary bud. As vegetables are immoveably fixed to the ſoil from whence they draw their mouriſhment ready prepared, and this uniformly not at returning intervals, it follows that in examining their anatome we are not to look for muſcles of locomotion, as arms and legs; nor for organs to receive and prepare their nouriſhment, as a ſtomach and bowels; nor for a reſervoir for it after it is prepared, as a general ſyſtem of veins, which in locomotive animals contains and returns the ſuperfluous blood which is left after the various organs of ſecretion have been ſupplied, by which contrivance they are enabled to live a long time without new ſupplies of food.

The parts which we may expect to find in the anatome of vegetables correſpondent to thoſe in the animal economy are, 1. A ſyſtem of abſorbent veſſels to imbibe the moiſture of the earth ſimilar to the lacteal veſſels, as in the roots of plants; and another ſyſtem of abſorbents ſimilar to the lymphatics of animal bodies, opening its mouths on the internal cells and external ſurfaces of vegetables; and a third ſyſtem of abſorbent veſſels correſpondent with thoſe of the placentation of the animal fœtus. 2. A pulmonary ſyſtem correſpondent to the lungs or gills of quadrupeds and fiſh, by which the fluid abſorbed by the lacteals and lymphatics may be expoſed to the influence of the air, this is done by the green leaves of plants, thoſe in the air reſembling lungs, and thoſe in the water reſembling gills; and by the petals of flowers. 3. Arterial ſyſtems to convey the fluid thus elaborated to the various glands of the vegetable for the purpoſes of its growth, nutrition, and various ſecretions. 4. The various glands which ſeparate from the vegetable blood the honey, wax, gum, reſin, ſtarch, ſugar, eſſential oil, &c. 5. The organs adapted for their propagation or reproduction. 6. Muſcles to perform ſeveral motions of their parts.

I. The exiftence of that branch of the abforbent veffels of vegetables which refembles the lacteals of animal bodies, and imbibes their nutriment from the moift earth, is evinced by their growth fo long as moifture is applied to their roots, and their quickly withering when it is withdrawn.

Befides thefe abforbents in the roots of plants there are others which open their mouths on the external furfaces of the bark and leaves, and on the internal furfaces of all the cells, and between the bark and the alburnum or fap-wood; the exiftence of thefe is fhewn, becaufe a leaf plucked off and laid with its under fide on water will not wither fo foon as if left in the dry air,—the fame if the bark alone of a branch which is feparated from a tree be kept moift with water,—and laftly, by moiftening the alburnum or fap-wood alone of a branch detached from a tree it will not fo foon wither as if left in the dry air. By the following experiment thefe veffels were agreeably vifible by a common magnifying glafs, I placed in the fummer of 1781 the footftalks of fome large fig-leaves about an inch deep in a decoction of madder, (rubia tinctorum,) and others in a decoction of logwood, (hæmatoxylum campechenfe,) along with fome fprigs cut off from a plant of picris, thefe plants were chofen becaufe their blood is white, after fome hours, and on the next day, on taking out either of thefe and cutting off from its bottom about a quarter of an inch of the ftalk an internal circle of red points appeared, which were the ends of abforbent veffels coloured red with the decoction, while an external ring of arteries was feen to bleed out haftily a milky juice, and at once evinced both the abforbent and arterial fyftem. Thefe abforbent veffels have been called by Grew, and Malphigi, and fome other philofophers, bronchi, and erroneoufly fuppofed to be air-veffels. It is probable that thefe veffels, when cut through, may effufe their fluids, and receive air, their fides being too ftiff to collapfe; fince dry wood emits air-bubles in the exhaufted receiver in the fame manner as moift wood.

The ftructure of thefe vegetable abforbents confifts of a fpiral line, and not of a veffel interrupted with valves like the animal lymphatics, fince on breaking almoft any tender leaf and drawing out fome of the fibres which adhere longeft this fpiral ftructure becomes vifible even to the naked eye, and diftinctly fo by the ufe of a common lens. See Grew, Plate 51.

In fuch a ftructure it is eafy to conceive how a vermicular, or periftaltic motion of the veffel beginning at the loweft part of it, each fpiral ring fucceffively contracting itfelf till it fills up the tube, muft forcibly pufh forwards its contents, as from the roots of vines in the bleeding feafon; and if this vermicular motion fhould begin at the upper end of the veffel it is as eafy to fee how it muft carry its contained fluid in a contrary direction. The retrograde motion of the vegetable abforbent veffels is fhewn by cutting a forked branch from a tree, and immerfing a part of one of the forks in water, which will for many days prevent the other from withering; or it is fhewn by planting a willow branch with the wrong end upwards. This ftructure in fome degree obtains in the efophagus or throat of cows, who by fimilar means convey their food firft downwards

and afterward upwards by a retrograde motion of the annular muscles or cartilages for the purpose of a second mastication of it.

II. The fluids thus drank up by the vegetable absorbent vessels from the earth, or from the atmosphere, or from their own cells and interstices, are carried to the foot-stalk of every leaf, where the absorbents belonging to each leaf unite into branches, forming so many pulmonary arteries, and are thence dispersed to the extremities of the leaf, as may be seen in cutting away slice after slice the footstalk of a horse-chesnut in September before the leaf falls. There is then a compleat circulation in the leaf, a pulmonary vein receiving the blood from the extremities of each artery on the upper side of the leaf, and joining again in the footstalk of the leaf these veins produce so many arteries, or aortas, which disperse the new blood over the new bark, elongating its vessels, or producing its secretions; but as a reservoir of blood could not be wanted by a vegetable bud which takes in its nutriment at all times, I imagine there is no venous system, no veins properly so called, which receive the blood which was to spare, and return it into the pulmonary or arterial system.

The want of a system of veins was countenanced by the following experiment; I cut off several stems of tall spurge, (Euphorbia helioscopia) in autumn, about the centre of the plant, and observed tenfold the quantity of milky juice ooze from the upper than from the lower extremity, which could hardly have happened if there had been a venous system of vessels to return the blood from the roots to the leaves.

Thus the vegetable circulation, complete in the lungs, but probably in the other part of the system deficient in respect to a system of returning veins, is carried forwards without a heart, like the circulation through the livers of animals where the blood brought from the intestines and mesentery by one vein is dispersed through the liver by the vena portarum, which assumes the office of an artery. See Note XXXVII.

At the same time so minute are the vessels in the intertexture of the barks of plants, which belong to each individual bud, that a general circulation may possibly exist, though we have not yet been able to discover the venous part of it.

There is however another part of the circulation of vegetable juices visible to the naked eye, and that is in the corol or petals of flowers, in which a part of the blood of the plant is exposed to the influence of the air and light in the same manner as in the foliage, as will be mentioned more at large in Notes XXXVII and XXXIX.

These circulations of their respective fluids seem to be carried on in the vessels of plants precisely as in animal bodies by their irritability to the stimulus of their adapted fluids, and not by any mechanical or chemical attraction, for their absorbent vessels propel the juice upwards, which they drink up from the earth, with great violence; I suppose with much greater than is exerted by the lacteals of animals, probably owing to the greater minuteness of these vessels in vegetables and the greater rigidity of their coats. Dr. Hales in the spring season cut off a vine near the ground, and by fixing tubes on the remaining stump of it, found the sap to rise twenty-one feet in the tube by the propulsive

power of these absorbents of the roots of it. Veget. Stat. p. 102. Such a power can not be produced by capillary attraction, as that could only raise a fluid nearly to the upper edge of the attracting cylinder, but not enable it to flow over that edge, and much less to rise 21 feet above it. What then can this power be owing to? Doubtless to the living activity of the absorbent vessels, and to their increased vivacity from the influence of the warmth of the spring succeeding the winter's cold, and their thence greater susceptibility to irritation from the juices which they absorb, resembling in all circumstances the action of the living vessels of animals.

NOTE XXXVII.——VEGETABLE RESPIRATION.

While spread in air the leaves respiring play. CANTO IV. l. 421.

I. THERE have been various opinions concerning the use of the leaves of plants in the vegetable œconomy: Some have contended that they are perspiratory organs; this does not seem probable from an experiment of Dr. Hales, Veg. Stat. p. 30. He found by cutting off branches of trees with apples on them, and taking off the leaves, that an apple exhaled about as much as two leaves, the surfaces of which were nearly equal to the apple; whence it would appear that apples have as good a claim to be termed perspiratory organs as leaves. Others have believed them excretory organs of excrementitious juices; but as the vapour exhaled from vegetables has no taste, this idea is no more probable than the other; add to this that in moist weather, they do not appear to perspire or exhale at all.

The internal surface of the lungs or air-vessels in men, are said to be equal to the external surface of the whole body, or about fifteen square feet; on this surface the blood is exposed to the influence of the respired air through the medium however of a thin pellicle; by this exposure to the air it has its colour changed from deep red to bright scarlet, and acquires something so necessary to the existence of life, that we can live scarcely a minute without this wonderful process.

The analogy between the leaves of plants and the lungs or gills of animals seems to embrace so many circumstances, that we can scarcely withhold our assent to their performing similar offices.

1. The great surface of the leaves compared to that of the trunk and branches of trees is such, that it would seem to be an organ well adapted for the purpose of exposing the vegetable juices to the influence of the air; this however we shall see afterwards is probably performed only by their upper surfaces, yet even in this case the surface of the leaves in general bear a greater proportion to the surface of the tree, than the lungs of animals to their external surfaces.

2. In the lungs of animal, the blood after having been expoſed to the air in the extremities of pulmonary artery, is changed in colour from deep red to bright ſcarlet, and certainly in ſome of its eſſential properties; it is then collected by the pulmonary vein and returned to the heart. To ſhew a ſimilarity of circumſtance in the leaves of plants the following experiment was made, June 24, 1781: A ſtalk with leaves and ſeed-veſſels of large ſpurge (Euphorbia helioſcopia) had been ſeveral days placed in a decoction of madder (Rubia tinctorum) ſo that the lower part of the ſtem, and two of the undermoſt leaves were immerſed in it. After having waſhed the immerſed leaves in clear water, I could readily diſcern the colour of the madder paſſing along the middle rib of each leaf. This red artery was beautifully viſible both on the under and upper ſurface of the leaf; but on the upper ſide many red branches were ſeen going from it to the extremities of the leaf, which on the other ſide were not viſible except by looking through it againſt the light. On this under ſide a ſyſtem of branching veſſels carrying a pale milky fluid were ſeen coming from the extremities of the leaf, and covering the whole underſide of it, and joining into two large veins, one on each ſide of the red artery in the middle rib of the leaf, and along with it deſcending to the footſtalk or petiole. On ſlitting one of theſe leaves with ſciſſars, and having a common magnifying lens ready, the milky blood was ſeen oozing out of the returning veins on each ſide of the red artery in the middle rib, but none of the red fluid from the artery.

All theſe appearances were more eaſily ſeen in a leaf of Picris treated in the ſame manner; for in this milky plant the ſtems and middle rib of the leaves are ſometimes naturally coloured reddiſh, and hence the colour of the madder ſeemed to paſs further into the ramifications of their leaf-arteries, and was there beautifully viſible with the returning branches of milky veins on each ſide.

3. From theſe experiments the upper ſurface of the leaf appeared to be the immediate organ of reſpiration, becauſe the coloured fluid was carried to the extremities of the leaf by veſſels moſt conſpicuous on the upper ſurface, and there changed into a milky fluid, which is the blood of the plant, and then returned by concomitant veins on the under ſurface, which were ſeen to ooze when divided with ſciſſars, and which in Picris, particularly render the under ſurface of the leaves greatly whiter than the upper one.

4. As the upper ſurface of leaves conſtitutes the organ of reſpiration, on which the ſap is expoſed in the terminations of arteries beneath a thin pellicle to the action of the atmoſphere, theſe ſurfaces in many plants ſtrongly repel moiſture, as cabbage-leaves, whence the particles of rain lying over their ſurfaces without touching them, as obſerved by Mr. Melville (Eſſays Literary and Philoſop. Edinburgh) have the appearance of globules of quickſilver. And hence leaves laid with the upper ſurfaces on water, wither as ſoon as in the dry air, but continue green many days, if placed with the under ſurfaces on water, as appears in the experiments of Monſ. Bonnet (Uſage des Fevilles.) Hence ſome aquatic plants, as the Water-lily (Nymphœa) have the lower ſides of their leaves floating on the water, while the upper ſurfaces remain dry in the air.

5. As thoſe inſects, which have many ſpiracula, or breathing apertures, as waſps and flies, are immediately ſuffocated by pouring oil upon them, I carefully covered with

oil the furfaces of feveral leaves of Phlomis, of Portugal Laurel, and Balfams, and though it would not regularly adhere, I found them all die in a day or two.

Of aquatic leaves, fee Note on Trapa and on Fucus, in Vol. II. to which muft be added that many leaves are furnifhed with mufcles about their footftalks, to turn their upper furfaces to the air or light, as Mimofa and Hedyfarum gyrans. From all thefe analogies I think there can be no doubt but that leaves of trees are their lungs, giving out a phlogiftic material to the atmofphere, and abforbing oxygene or vital air.

6. The great ufe of light to vegetation would appear from this theory to be by difengaging vital air from the water which they perfpire, and thence to facilitate its union with their blood expofed beneath the thin furface of their leaves; fince when pure air is thus applied, it is probable, that it can be more readily abforbed. Hence in the curious experiments of Dr. Prieftley and Mr. Ingenhouze, fome plants purified air lefs than others, that is, they perfpired lefs in the funfhine; and Mr. Scheele found that by putting peas into water, which about half-covered them, that they converted the vital air into fixed air, or carbonic acid gas, in the fame manner as in animal refpiration. See Note XXXIV.

7. The circulation in the lungs or leaves of plants is very fimilar to that of fifh. In fifh the blood after having paffed through their gills does not return to the heart as from the lungs of air-breathing animals, but the pulmonary vein taking the ftructure of an artery after having received the blood from the gills, which there gains a more florrid colour, diftributes it to the other parts of their bodies. The fame ftructure occurs in the livers of fifh, whence we fee in thofe animals two circulations independent of the power of the heart, viz. that beginning at the termination of the veins of the gills, and branching through the mufcles; and that which paffes through the liver; both which are carried on by the action of thofe refpective arteries and veins. Monro's Phyfiology of Fifh, p. 19.

The courfe of the fluids in the roots, leaves, and buds of vegetables feems to be performed in a manner fimilar to both thefe. Firft the abforbent veffels of the roots and furfaces unite at the footftalk of the leaf; and then, like the Vena Portarum, an artery commences without the intervention of a heart, and fpreads the fap in its numerous ramifications on the upper furface of the leaf; here it changes its colour and properties, and becomes vegetable blood; and is again collected by a pulmonary vein on the under furface of the leaf. This vein, like that which receives the blood from the gills of fifh, affumes the office and name of an artery, and branching again difperfes the blood upward to the bud from the footftalk of the leaf, and downward to the roots; where it is all expended in the various fecretions, the nourifhment and growth of the plant, as faft as it is prepared.

II. The organ of refpiration already fpoken of belongs particularly to the fhoots or buds, but there is another pulmonary fyftem, perhaps totally independent of the green foliage, which belongs to the fructification only, I mean the corol or petals. In this there is an artery belonging to each petal, which conveys the vegetable blood to its extremities, expofing it to the light and air under a delicate membrane covering the internal furface of the petal, where it often changes its colour, as is beautifully feen in fome party-

coloured poppies; though it is probable some of the iridescent colours of flowers may be owing to the different degrees of tenuity of the exterior membrane of the leaf refracting the light like soap-bubbles, the vegetable blood is then returned by correspondent vegetable veins, exactly as in the green foliage; for the purposes of the important secretions of honey, wax, the finer essential oil, and the prolific dust of the anthers.

1. The vascular structure of the corol as above described, and which is visible to the naked eye, and its exposing the vegetable juices to the air and light during the day, evinces that it is a pulmonary organ.

2. As the glands which produce the prolific dust of the anthers, the honey, wax, and frequently some odoriferous essential oil, are generally attached to the corol, and always fall off and perish with it, it is evident that the blood is elaborated or oxygenated in this pulmonary system for the purpose of these important secretions.

3. Many flowers, as the Colchicum, and Hamamelis arise naked in autumn, no green leaves appearing till the ensuing spring; and many others put forth their flowers and complete their impregnation early in the spring before the green foliage appears, as Mezereon, cherries, pears, which shews that these corols are the lungs belonging to the fructification.

4. This organ does not seem to have been necessary for the defence of the stamens and pistils, since the calyx of many flowers, as Tragopogon, performs this office; and in many flowers these petals themselves are so tender as to require being shut up in the calyx during the night, for what other use then can such an apparatus of vessels be designed?

5. In the Helleborus-niger, Christmas-rose, after the seeds are grown to a certain size, the nectaries and stamens drop off, and the beautiful large white petals change their colour to a deep green, and gradually thus become a calyx inclosing and defending the ripening seeds, hence it would seem that the white vessels of the corol served the office of exposing the blood to the action of the air, for the purposes of separating or producing the honey, wax, and prolific dust, and when these were no longer wanted, that these vessels coalesced like the placental vessels of animals after their birth, and thus ceased to perform that office and lost at the same time their white colour. Why should they loose their white colour, unless they at the same time lost some other property besides that of defending the seed-vessel, which they still continue to defend?

6. From these observations I am led to doubt whether green leaves be absolutely necessary to the progress of the fruit-bud after the last year's leaves are fallen off. The green leaves serve as lungs to the shoots and foster the new buds in their bosoms, whether these buds be leaf-buds or fruit-buds; but in the early spring the fruit-buds expand their corols, which are their lungs, and seem no longer to require green leaves; hence the vine bears fruit at one joint without leaves, and puts out a leaf bud at another joint without fruit. And I suppose the green leaves which rise out of the earth in the spring from the Colchicum are for the purpose of producing the new bulb, and its placenta, and not for the giving maturity to the seed. When currant or goosberry trees lose their leaves by the depredation of insects the fruit continues to be formed, though less sweet and less in size.

7. From these facts it appears that the flower-bud after the corol falls off, (which is its lungs,) and the stamens and nectary along with it, becomes simply an uterus for the purpose of supplying the growing embryon with nourishment, together with a system of absorbent vessels which bring the juices of the earth to the footstalk of the fruit, and which there changes into an artery for the purpose of distributing the sap for the secretion of the saccharine or farinaceous or acescent materials for the use of the embryon. At the same time as all the vessels of the different buds of trees inosculate or communicate with each other, the fruit becomes sweeter and larger when the green leaves continue on the tree, but the mature flowers themselves, (the succeeding fruit not considered) perhaps suffer little injury from the green leaves being taken off, as some florists have observed.

8. That the vessels of different vegetable buds inosculate in various parts of their circulation is rendered probable by the increased growth of one bud, when others in its vicinity are cut away; as it thus seems to receive the nourishment which was before divided amongst many.

NOTE XXXVIII.——VEGETABLE IMPREGNATION.

Love out their hour and leave their lives in air. CANTO IV. l. 456.

FROM the accurate experiments and observations of Spallanzani it appears that in the Spartium Junceum, rush-broom, the very minute seeds were discerned in the pod at least twenty days before the flower is in full bloom, that is twenty days before fecundation. At this time also the powder of the anthers was visible, but glued fast to their summits. The seeds however at this time, and for ten days after the blossom had fallen off, appeared to consist of a gelatinous substance. On the eleventh day after the falling of the blossom the seeds became heart-shape, with the basis attached by an appendage to the pod, and a white point at the apex; this white point was on pressure found to be a cavity including a drop of liquor.

On the 25th day the cavity which at first appeared at the apex was much enlarged and still full of liquor, it also contained a very small semi-transparent body, of a yellowish colour, gelatinous, and fixed by its two opposite ends to the sides of the cavity.

In a month the seed was much enlarged and its shape changed from a heart to a kidney, the little body contained in the cavity was increased in bulk and was less transparent, and gelatinous, but there yet appeared no organization.

On the 40th day the cavity now grown larger was quite filled with the body, which was covered with a thin membrane; after this membrane was removed the body appeared of a bright green, and was eafily divided by the point of a needle into two portions, which manifeftly formed the two lobes, and within thefe attached to the lower part the exceedingly fmall plantule was eafily perceived.

The foregoing obfervations evince, 1. That the feeds exift in the ovarium many days before fecundation. 2. That they remain for fome time folid, and then a cavity containing a liquid is formed in them. 3. That after fecundation a body begins to appear within the cavity fixed by two points to the fides, which in procefs of time proves to be two lobes containing a plantule. 4. That the ripe feed confifts of two lobes adhering to a plantule, and furrounded by a thin membrane which is itfelf covered with a hufk or cuticle. Spalanzani's Differtations, Vol. II. p. 253.

The analogy between feeds and eggs has long been obferved, and is confirmed by the mode of their production. The egg is known to be formed within the hen long before its impregnation; C. F. Wolf afferts that the yolk of the egg is nourifhed by the veffels of the mother, and that it has from thofe its arterial and venous branches, but that after impregnation thefe veffels gradually become impervious and obliterated, and that new ones are produced from the fetus and difperfed into the yolk. Haller's Phyfiolog. Tom. VIII. p. 94. The young feed after fecundation, I fuppofe, is nourifhed in a fimilar manner from the gelatinous liquor, which is previoufly depofited for that purpofe; the uterus of the plant producing or fecreting it into a refervoir or amnios in which the embryon is lodged, and that the young embryon is furnifhed with veffels to abforb a part of it, as in the very early embryon in the animal uterus.

The fpawn of frogs and of fifh is delivered from the female before its impregnation. M. Bonnet fays that the male falamander darts his femen into the water, where it forms a little whitifh cloud which is afterwards received by the fwoln anus of the female, and fhe is fecundated.—He adds, that marine plants approach near to thefe animals, as the male does not project a fine powder but a liquor which in like manner forms a little cloud in the water.—And further adds, who knows but the powder of the ftamina of certain plants may not make fome impreffion on certain germs belonging to the animal kingdom! Letter XLIII. to Spalanzani, Oevres Philof.

Spalanzani found that the feminal fluid of frogs and dogs even when diluted with much water retained its prolific quality. Whether this quality be fimply a ftimulus exciting the egg into animal action, which may be called a vivifying principle, or whether part of it be actually conjoined with the egg is not yet determined, though the latter feems more probable from the frequent refemblance of the fetus to the male parent. A conjunction however of both the male and female influence feems neceffary for the purpofe of reproduction throughout all organized nature, as well in hermaphrodite infects, microfcopic animals, and polypi, and exifts as well in the formation of the buds of vegetables as in the production of their feeds, which is ingenioufly conceived and explained by Linneus. After having compared the flower to the larva of a butterfly,

consisting of petals instead of wings, calyxes instead of wing-sheaths, with the organs of reproduction, and having shewn the use of the farina in fecundating the egg or seed, he proceeds to explain the production of the bud. The calyx of a flower, he says, is an expansion of the outer bark, the petals proceed from the inner bark or rind, the stamens from the alburnum or woody circle, and the style from the pith. In the production and impregnation of the seed a commixture of the secretions of the stamens and style are necessary; and for the production of a bud he thinks the medulla or pith bursts its integuments and mixes with the woody part or alburnum, and these forcing their passage through the rind and bark constitute the bud or viviparous progeny of the vegetable. System of Vegetables translated from Linneus, p. 8.

It has been supposed that the embryon vegetable after fecundation, by its living activity or stimulus exerted on the vessels of the parent plant, may produce the fruit or seed-lobes, as the animal fetus produces its placenta, and as vegetable buds may be supposed to produce their umbilical vessels or roots down the bark of the tree. This in respect to the production of the fruit surrounding the seeds of trees has been assimilated to the gall-nuts on oak-leaves, and to the bedeguar on briars, but there is a powerful objection to this doctrine, viz. that the fruit of figs, all which are female in this country, grow nearly as large without fecundation, and therefore the embryon has in them no self-living principle.

NOTE XXXIX.— VEGETABLE GLANDULATION.

Seeks, where fine pores their dulcet balm distil. CANTO IV. l. 503.

THE glands of vegetables which separate from their blood the mucilage, starch, or sugar, for the placentation or support of their seeds, bulbs, and buds; or those which deposit their bitter, acrid, or narcotic juices for their defence from depredations of insects or larger animals; or those which secrete resins or wax for their protection from moisture or frosts, consist of vessels too fine for the injection or absorption of coloured fluids, and have not therefore yet been exhibited to the inspection even of our glasses, and can therefore only be known by their effects, but one of the most curious and important of all vegetable secretions, that of honey, is apparent to our naked eyes, though before the discoveries of Linneus the nectary or honey-gland had not even acquired a name.

The odoriferous essential oils of several flowers seem to have been designed for their defence against the depredations of insects, while their beautiful colours were a necessary consequence of the size of the particles of their blood, or of the tenuity of the exterior membrane of the petal. The use of the prolific dust is now well ascertained, the wax which covers the anthers prevents this dust from receiving moisture, which would make it burst prematurely and thence prevent its application to the stigma, as sometimes happens in moist years and is the cause of deficient fecundation both of our fields and orchards.

The universality of the production of honey in the vegetable world, and the very complicated apparatus which nature has constructed in many flowers, as well as the acrid or deleterious juices she has furnished those flowers with (as in the Aconite) to protect this honey from rain and from the depredations of insects, seem to imply that this fluid is of very great importance in the vegetable economy; and also that it was necessary to expose it to the open air previous to its reabsorption into the vegetable vessels.

In the animal system the lachrymal gland separates its fluid into the open air for the purpose of moistening the eye, of this fluid the part which does not exhale is absorbed by the puncta lachrymalia and carried into the nostrils; but as this is not a nutritive fluid the analogy goes no further than its secretion into the open air and its reabsorption into the system; every other secreted fluid in the animal body is in part absorbed again into the system, even those which are esteemed excrementitious, as the urine and perspirable matter, of which the latter is secreted, like the honey, into the external air. That the honey is a nutritious fluid, perhaps the most so of any vegetable production, appears from its great similarity to sugar, and from its affording sustenance to such numbers of insects, which live upon it solely during summer, and lay it up for their winter provision. These proofs of its nutritive nature evince the necessity of its reabsorption into the vegetable system for some useful purpose.

This purpose however has as yet escaped the researches of philosophical botanists. M. Pontedera believes it designed to lubricate the vegetable uterus, and compares the horn-like nectaries of some flowers to the appendicle of the cæcum intestinum of animals. Antholog. p. 49.) Others have supposed that the honey, when reabsorbed, might serve the purpose of the liquor amnii, or white of the egg, as a nutriment for the young embryon or fecundated seed in its early state of existence. But as the nectary is found equally general in male flowers as in female ones; and as the young embryon or seed grows before the petals and nectary are expanded, and after they fall off; and, thirdly, as the nectary so soon falls off after the fecundation of the pistillum; these seem to be insurmountable objections to both the above-mentioned opinions.

In this state of uncertainty conjectures may be of use so far as they lead to further experiment and investigation. In many tribes of insects, as the silk-worm, and perhaps in all the moths and butterflies, the male and female parents die as soon as the eggs are

impregnated and excluded; the eggs remaining to be perfected and hatched at some future time. The same thing happens in regard to the male and female parts of flowers; the anthers and filaments, which constitute the male parts of the flower, and the stigma and style, which constitute the female part of the flower, fall off and die as soon as the seeds are impregnated, and along with these the petals and nectary. Now the moths and butterflies above-mentioned, as soon as they acquire the passion and the apparatus for the reproduction of their species, loose the power of feeding upon leaves as they did before, and become nourished by what?---by honey alone.

Hence we acquire a strong analogy for the use of the nectary or secretion of honey in the vegetable economy, which is, that the male parts of flowers, and the female parts, as soon as they leave their fetus-state, expanding their petals, (which constitute their lungs,) become sensible to the passion, and gain the apparatus for the reproduction of their species, and are fed and nourished with honey like the insects above described; and that hence the nectary begins its office of producing honey, and dies or ceases to produce honey at the same time with the birth and death of the stamens and the pistils; which, whether existing in the same or in different flowers, are separate and distinct animated beings.

Previous to this time the anthers with their filaments, and the stigmas with their styles, are in their fetus-state sustained by their placental vessels, like the unexpanded leaf-bud; with the seeds existing in the vegetable womb yet unimpregnated, and the dust yet unripe in the cells of the anthers. After this period they expand their petals, which have been shewn above to constitute the lungs of the flower; the placental vessels, which before nourished the anthers and the stigmas, coalesce or cease to nourish them; and they now acquire blood more oxygenated by the air, obtain the passion and power of reproduction, are sensible to *heat*, and *cold*, and *moisture*, and to mechanic stimulus, and become in reality insects fed with honey, similar in every respect except their being attached to the tree on which they were produced.

Some experiments I have made this summer by cutting out the nectaries of several flowers of the aconites before the petals were open, or had become much coloured, some of these flowers near the summit of the plants produced no seeds, others lower down produced seeds; but they were not sufficiently guarded from the farina of the flowers in their vicinity; nor have I had opportunity to try if these seeds would vegetate.

I am acquainted with a philosopher, who contemplating this subject thinks it not impossible, that the first insects were the anthers or stigmas of flowers; which had by some means loosed themselves from their parent plant, like the male flowers of Vallisneria; and that many other insects have gradually in long process of time been formed from these; some acquiring wings, others fins, and others claws, from their ceaseless efforts to procure their food, or to secure themselves from injury. He contends, that none of these changes are more incomprehensible than the transformation of tadpoles into frogs, and caterpillars into butterflies.

There are parts of animal bodies, which do not require oxygenated blood for the purpose of their secretions, as the liver; which for the production of bile takes its blood

from the mesenteric veins, after it must have lost the whole or a great part of its oxygenation, which it had acquired in its passage through the lungs. In like manner the pericarpium, or womb of the flower, continues to secrete its proper juices for the present nourishment of the newly animated embryon-seed; and the saccharine, acescent, or starchy matter of the fruit or seed-lobes for its future growth; in the same manner as these things went on before fecundation; that is, without any circulation of juices in the petals, or production of honey in the nectary; these having perished and fallen off with the male and female apparatus for impregnation.

It is probable that the depredations of insects on this nutritious fluid must be injurious to the products of vegetation, and would be much more so, but that the plants have either acquired means to defend their honey in part, or have learned to make more than is absolutely necessary for their own economy. In the same manner the honey-dew on trees is very injurions to them; in which disease the nutritive fluid, the vegetable-sap-juice, seems to be exsuded by a retrograde motion of the cutaneous lymphatics, as in the sweating sickness of the last century. To prevent the depredation of insects on honey a wealthy man in Italy is said to have poisoned his neighbour's bees perhaps by mixing arsnic with honey, against which there is a most flowery declamation in Quintilian. No. XIII. As the use of the wax is to preserve the dust of the anthers from moisture, which would prematurely burst them, the bees which collect this for the construction of the combs or cells, must on this account also injure the vegetation of a country where they too much abound.

It is not easy to conjecture why it was necessary that this secretion of honey should be exposed to the open air in the nectary or honey-cup, for which purpose so great an apparatus for its defence from insects and from showers became necessary. This difficulty increases when we recollect that the sugar in the joints of grass, in the sugar-cane, and in the roots of beets, and in ripe fruits is produced without the exposure to the air. On supposition of its serving for nutriment to the anthers and stigmas it may thus acquire greater oxygenation for the purpose of producing greater powers of sensibility, according to a doctrine lately advanced by a French philosopher, who has endeavoured to shew that the oxygene, or base of vital air, is the constituent principle of our power of sensibility.

From this provision of honey for the male and female parts of flowers, and from the provision of sugar, starch, oil, and mucilage, in the fruits, seed-cotyledons, roots, and buds of plants laid up for the nutriment of the expanding fetus, not only a very numerous class of insects, but a great part of the larger animals procure their food; and thus enjoy life and pleasure without producing pain to others, for these seeds or eggs with the nutriment laid up in them are not yet endued with sensitive life.

The secretions from various vegetable glands hardened in the air produce gums, resins, and various kinds of saccharine, saponaceous, and wax-like substances, as the gum of cherry or plumb-trees, gum tragacanth from the astragalus tragacantha, camphor from the laurus camphora, elemi from amyris elemifera, aneme from hymenaea courbaril, turpentine from pistacia terebinthus, balsam of Mecca from the buds of amyris opobal-

famum, branches of which are placed in the temples of the Eaft on account of their fragrance, the wood is called xylobalfamum, and the fruit carpobalfamum; aloe from a plant of the fame name; myrrh from a plant not yet defcribed; the remarkably elaftic refin is brought into Europe principally in the form of flafks, which look like black leather, and are wonderfully elaftic, and not penetrable by water, rectified ether diffolves it; its flexibility is encreafed by warmth and deftroyed by cold; the tree which yields this juice is the jatropha elaftica, it grows in Guaiana and the neighbouring tracts of America; its juice is faid to refemble wax in becoming foft by heat, but that it acquires no elafticity till that property is communicated to it by a fecret art, after which it is poured into moulds and well dried and can no longer be rendered fluid by heat. Mr. de la Borde phyfician at Cayenne has given this account. Manna is obtained at Naples from the fraxinus ornus, or manna-afh, it partly iffues fpontaneoufly, which is preferred, and partly exfudes from wounds made purpofely in the month of Auguft, many other plants yield manna more fparingly; fugar is properly made from the faccharum officinale, or fugar-cane, but is found in the roots of beet and many other plants; American wax is obtained from the myrica cerifera, candle-berry myrtle, the berries are boiled in water and a green wax feparates, with luke-warm water the wax is yellow: the feed of croton febiferum are lodged in tallow; there are many other vegetable exfudations ufed in the various arts of dyeing, varnifhing, tanning, lacquering, and which fupply the fhop of the druggift with medicines and with poifons.

There is another analogy, which would feem to affociate plants with animals, and which perhaps belongs to this Note on Glandulation, I mean the fimilarity of their digeftive powers. In the roots of growing vegetables, as in the procefs of making malt, the farinaceous part of the feed is converted into fugar by the vegetable power of digeftion in the fame manner as the farinaceous matter of feeds are converted into fweet chyle by the animal digeftion. The fap-juice which rifes in the vernal months from the roots of trees through the alburnum or fap-wood, owes its fweetnefs I fuppofe to a fimilar digeftive power of the abforbent fyftem of the young buds. This exifts in many vegetables in great abundance as in vines, fycamore, birch, and moft abundantly in the palm-tree, (Ifert's Voyage to Guinea,) and feems to be a fimilar fluid in all plants, as chyle is fimilar in all animals.

Hence as the digefted food of vegetables confifts principally of fugar, and from that is produced again their mucilage, ftarch, and oil, and fince animals are fuftained by thefe vegetable productions, it would feem that the fugar-making procefs carried on in vegetable veffels was the great fource of life to all organized beings. And that if our improved chemiftry fhould ever difcover the art of making fugar from foffile or aerial matter without the affiftance of vegetation, food for animals would then become as plentiful as water, and mankind might live upon the earth as thick as blades of grafs, with no reftraint to their numbers but the want of local room.

It would feem that roots fixed in the earth, and leaves innumerable waving in the air were neceffary forthe decompofition of water, and the converfion of it into faccharine

matter, which would have been not only cumberous but totally incompatible with the locomotion of animal bodies. For how could a man or quadruped have carried on his head or back a foreſt of leaves, or have had long branching lacteal or abſorbent veſſels terminating in the earth? Animals therefore ſubſiſt on vegetables; that is, they take the matter ſo far prepared, and have organs to prepare it further for the purpoſes of higher animation, and greater ſenſibility. In the ſame manner the apparatus of green leaves and long roots were found inconvenient for the more animated and ſenſitive parts of vegetable-flowers, I mean the anthers and ſtigmas, which are therefore ſeparate beings, endued with the paſſion and power of reproduction, with lungs of their own, and fed with honey, a food ready prepared by the long roots and green leaves of the plant, and preſented to their abſorbent mouths.

From this outline a philoſopher may catch a glimpſe of the general economy of nature; and like the mariner caſt upon an unknown ſhore, who rejoiced when he ſaw the print of a human foot upon the ſand, he may cry out with rapture, "A God dwells "here."

The following is an Addition to the Note on Coal, No. XXIII.

FROM this account of the production of coals from morasses it would appear, that coal-beds are not to be expected beneath masses of lime-stone. Nevertheless I have been lately informed by my friend Mr. Michell of Thornhill, who I hope will soon favour the public with his geological investigations, that the beds of chalk are the uppermost of all the limestones; and that they rest on the granulated limestone, called Ketton-stone; which I suppose is similar to that which covers the whole country from Leadenham to Sleaford, and from Sleaford to Lincoln; and that, thirdly, coal-delphs are frequently found beneath these two uppermost beds of limestone.

Now as the beds of chalk and of granulated limestone may have been formed by alluviation, on or beneath the shores of the sea, or in vallies of the land; it would seem, that some coal countries, which in the great commotions of the earth had been sunk beneath the water, were thus covered with alluvial limestone, as well as others with alluvial basaltes, or common gravel-beds. Very extensive plains which now consist of alluvial materials, were in the early times covered with water; which has since diminished, as the solid parts of the earth have increased. For the solid parts of the earth consisting chiefly of animal and vegetable recrements must have originally been formed or produced from the water by animal and vegetable processes; and as the solid parts of the earth may be supposed to be thrice as heavy as water, it follows that thrice the quantity of water must have vanished compared with the quantity of earth thus produced. This may account for many immense beds of alluvial materials, as gravel, rounded sand, granulated limestone, and chalk, covering such extensive plains as Lincoln-heath, having become dry without the supposition of their having been again elevated from the ocean. At the same time we acquire the knowledge of one of the uses or final causes of the organized world, not indeed very flattering to our vanity, that it converts water into earth, forming islands and continents by its recrements or exuviæ.

NOTES OMITTED.

Expiring groans. p. 98. l. 451. Mr. Savery or Mr. Volney in their Travels through Egypt has given a curious defcription of one of the pyramids, with the operofe method of clofing them, and immuring the body, (as they fuppofed) for fix thoufand years. And has endeavoured from thence to fhew, that, when a monarch died, feveral of his favourite courtiers were inclofed alive with the mummy in thefe great maffes of ftone-work; and had food and water conveyed to them, as long as they lived, proper apertures being left for this purpofe, and for the admiffion of air, and for the exclufion of any thing offenfive.

Unfolds his larva-form. p. 197. l. 458. The flower burfts forth from its larva, the herb, naked and perfect like a butterfly from its chryfolis; winged with its corol; wing-fheathed by its calyx; confifting alone of the organs of reproduction. The males, or ftamens, have their anthers replete with a prolific powder containing the vivifying fovilla: in the females, or piftils, exifts the ovary, terminated by the tubular ftigma. When the anthers burft and fhed their bags of duft, the male fovilla is received by the prolific lymph of the ftigma, and produces the feed or egg, which is nourifhed in the ovary. Syftem of Vegetables tranflated from Linneus by the Lichfield Society. p. 10.

Wound them ye Sylphs! p. 198. l. 463. It is cuftomary to debark oak-trees in the fpring, which are intended to be felled in the enfuing autumn; becaufe the bark comes off eafier at this feafon, and the fap-wood, or alburnum, is believed to become harder and more durable, if the tree remains till the end of fummer. The trees thus ftripped of their bark put forth fhoots as ufual with acorns on the 6th 7th and 8th joint, like vines; but in the branches I examined, the joints of the debarked trees were much fhorter than thofe of other oak-trees; the acorns were more numerous; and no new buds were produced above the joints which bore acorns. From hence it appears that the branches of debarked oak-trees produce fewer leaf-buds, and more flower-buds, which laft circumftance I fuppofe muft depend on their being fooner or later debarked in the vernal months. And, fecondly, that the new buds of debarked oak-trees continue to obtain moifture from the alburnum after the feafon of the afcent of fap in other vegetables ceafes; which in this unnatural ftate of the debarked tree may act as capillary tubes, like the alburnum of the fmall debarked cylinder of a pear-tree abovementioned; or may continue to act as placental veffels, as happens to the animal embryon in cafes of fuperfetation; when the fetus continues a month or two in the womb beyond its ufual time, of which fome inftances have been recorded, the placenta continues to fupply perhaps the double office both of nutrition and of refpiration.

With new prolific power. p. 199. l. 467. About Midsummer the new buds are formed, but it is believed by some of the Linnean school, that these buds may in their early state be either converted into flower-buds or leaf-buds according to the vigour of the vegetating branch. Thus if the upper part of a branch be cut away, the buds near the extremity of the remaining stem, having a greater proportional supply of nutriment, or possessing a greater facility of shooting their roots, or absorbent vessels, down the bark, will become leaf-buds, which might otherwise have been flower-buds. And the contrary as explained in note on l. 463. of this Canto.

Closed in the style. p. 199. l. 469. " I conceive the medulla of a plant to consist of a bundle of nervous fibres, and that the propelling vital power separates their uppermost extremities. These, diverging, penetrate the bark, which is now gelatinous, and become multiplied in the new gem, or leaf-bud. The ascending vessels of the bark being thus divided by the nervous fibres, which perforate it, and the ascent of its fluids being thus impeded, the bark is extended into a leaf. But the flower is produced, when the protrusion of the medulla is greater than the retention of the including cortical part; whence the substance of the bark is expanded in the calyx; that of the rind, (or interior bark,) in the corol; that of the wood in the stamens, that of the medulla in the pistil. Vegetation thus terminates in the production of new life, the ultimate medullary and cortical fibres being collected in the seeds." Linnei Systema Veget. p. 6. edit. 14.

Diana's trees. p. 206. l. 552. The chemists and astronomers from the earliest antiquity have used the same characters to represent the metals and the planets, which were most probably outlines or abstracts of the original hieroglyphic figures of Egypt. These afterwards acquired niches in their temples, and represented Gods as well as metals and planets; whence silver is called Diana, or the moon, in the books of alchemy.

The process for making Diana's silver tree is thus described by Lemeri. Dissolve one ounce of pure silver in acid of nitre very pure and moderately strong; mix this solution with about twenty ounces of distilled water; add to this two ounces of mercury, and let it remain at rest. In about four days there will form upon the mercury a tree of silver with branches imitating vegetation.

1. As the mercury has a greater affinity than silver with the nitrous acid, the silver becomes precipitated; and, being deprived of the nitrous oxygene by the mercury, sinks down in its metallic form and lustre. 2. The attraction between silver and mercury, which causes them readily to amalgamate together, occasions the precipitated silver to adhere to the surface of the mercury in preference to any other part of the vessel. 3. The attraction of the particles of the precipitated silver to each other causes the beginning branches to thicken and elongate into trees and shrubs rooted on the mercury. For other circumstances concerning this beautiful experiment see Mr. Keir's Chemical Dictionary, art. Arbor Dianæ; a work perhaps of greater utility to mankind than the lost Alexandrian Library; the continuation of which is so eagerly expected by all, who are occupied in the arts, or attached to the sciences.

CONTENTS

OF THE

ADDITIONAL NOTES.

NOTE I.....METEORS.

THERE are four ſtrata of the atmoſphere, and four kinds of meteors. 1. Lightning is electric, exiſts in viſible clouds, its ſhort courſe, and red light. 2. Shooting ſtars exiſt in inviſible vapour, without ſound, white light, have no luminous trains. 3. Twilight; fire-balls move thirty miles in a ſecond, and are about ſixty miles high, have luminous trains, occaſioned by an electric ſpark paſſing between the aerial and inflammable ſtrata of the atmoſphere, and mixing them and ſetting them on fire in its paſſage; attracted by volcanic eruptions; one thouſand miles through ſuch a medium reſiſts leſs than the tenth of an inch of glaſs. 4. Northern lights not attracted to a point but diffuſed; their colours; paſſage of electric fire in vacuo dubious; Dr. Franklin's theory of of northern lights countenanced in part by the ſuppoſition of a ſuperior atmoſphere of inflammable air; antiquity of their appearance; deſcribed in Maccabees.

NOTE II.....PRIMARY COLOURS.

THE rainbow was in part underſtood before Sir Iſaac Newton; the ſeven colours were diſcovered by him; Mr. Galton's experiments on colours; manganeſe and lead produce colourleſs glaſs.

NOTE III.....COLOURED CLOUDS.

THE rays refracted by the convexity of the atmoſphere; the particles of air and of water are blue; ſhadow by means of a candle in the day; halo round the moon in a fog; bright ſpot in the cornea of the eye; light from cat's eyes in the dark, from a horſe's eyes in a cavern, coloured by the choroid coat within the eye.

NOTE IV.....COMETS.

TAILS of comets from rarified vapour, like northern lights, from electricity; twenty millions of miles long; expected comet.

Note V.....Sun's Rays.

Dispute about phlogifton; the fun the fountain from whence all phlogifton is derived; its rays not luminous till they arrive at our atmofphere; light owing to their combuftion with air, whence an unknown acid; the fun is on fire only on its furface; the dark fpots on it are excavations through its luminous cruft.

Note VI.....Central Fires.

Sun's heat much lefs than that from the fire at the earth's centre; fun's heat penetrates but a few feet in fummer; fome mines are warm; warm fprings owing to fubterraneous fire; fituations of volcanos on high mountains; original nucleus of the earth; deep vallies of the ocean; diftant perception of earthquakes; great attraction of mountains; variation of the compafs; countenance the exiftence of a cavity or fluid lava within the earth.

Note VII.... Elementary Heat.

Combined and fenfible heat; chemical combinations attract heat, folutions reject heat; ice cools boiling water fix times as much as cold water cools it; cold produced by evaporation; heat by devaporation; capacities of bodies in refpect to heat, 1. Exiftence of the matter of heat fhewn from the mechanical condenfation and rarefaction of air, from the fteam produced in exhaufting a receiver, fnow from rarefied air, cold from difcharging an air-gun, heat from vibration or friction; 2. Matter of heat analogous to the electric fluid in many circumftances, explains many chemical phenomena.

Note VIII.....Memnon's Lyre.

Mechanical impulfe of light dubious; a glafs tube laid horizontally before a fire revolves; pulfe-glafs fufpended on a centre; black leather contracts in the funfhine; Memnon's ftatue broken by Cambyfes.

Note IX.....Luminous Insects.

Eighteen fpecies of glow-worm, their light owing to their refpiration in tranfparent lungs; Acudia of Surinam gives light enough to read and draw by, ufe of its light to the infect; luminous fea-infects adhere to the fkin of thofe who bathe in the ports of Languedoc, the light may arife from putrefcent flime.

Note X.....Phosphorus.

Discovered by Kunkel, Brandt, and Boyle; produced in refpiration, and by luminous infects, decayed wood, and calcined fhells; bleaching a flow combuftion in which the water is decompofed; rancidity of animal fat owing to the decompofition of water on its furface; aerated marine acid does not whiten or bleach the hand.

Note XI.....Steam-Engine.

Hero of Alexandria first applied steam to machinery, next a French writer in 1630, the Marquis of Worcester in 1655, Capt. Savery in 1689, Newcomen and Cawley added the piston; the improvements of Watt and Boulton; power of one of their large engines equal to two hundred horses.

Note XII.....Frost.

Expansion of water in freezing; injury done by vernal frosts; fish, eggs, seeds, resist congelation; animals do not resist the increase of heat; frosts do not meliorate the ground, nor are in general salubrious; damp air produces cold on the skin by evaporation; snow less pernicious to agriculture than heavy rains for two reasons.

Note XIII.....Electricity.

1. *Points* preferable to knobs for defence of buildings; why points emit the electric fluid; diffusion of oil on water; mountains are points on the earth's globe; do they produce ascending currents of air? 2. *Fairy-riggs* explained; advantage of paring and burning ground.

Note XIV.....Buds and Bulbs.

A Tree is a swarm of individual plants; vegetables are either oviparous or viviparous; are all annual productions like many kinds of insects? Hybernacula, a new bark annually produced over the old one in trees and in some herbaceous plants, whence their roots seem worm-bitten; all bulbous roots perish annually; experiment on a tulip-root; both the leaf-bulbs and the flower-bulbs are annually renewed.

Note XV.....Solar Volcanos.

The spots in the sun are cavities, some of them four thousand miles deep and many times as broad; internal parts of the sun are not in a state of combustion; volcanos visible in the sun; all the planets together are less than one six hundred and fiftieth part of the sun; planets were ejected from the sun by volcanos; many reasons shewing the probability of this hypothesis; Mr. Buffon's hypothesis that planets were struck off from the sun by comets; why no new planets are ejected from the sun; some comets and the georgium sidus may be of later date; Sun's matter decreased; Mr. Ludlam's opinion, that it is possible the moon might be projected from the earth.

Note XVI.....Calcareous Earth.

High mountains and deep mines replete with shells; the earth's nucleus covered with limestone; animals convert water into limestone; all the calcareous earth in the world formed in animal and vegetable bodies; solid parts of the earth increase; the water decreases; tops of calcareous mountains dissolved; whence spar, marbles, chalk, stalactites; whence alabaster, fluor, flint, granulated limestone, from solution of their angles, and by attrition; tupha deposited on moss; limestones from shells with animals

in them; liver-ſtone from freſh-water muſcles; calcareous earth from land-animals and vegetables, as marl; beds of marble ſoftened by fire; whence Bath-ſtone contains lime as well as limeſtone.

NOTE XVII.....MORASSES.

THE production of moraſſes from fallen woods; account by the Earl Cromartie of a new moraſs; moraſſes loſe their ſalts by ſolution in water; then their iron; their vegetable acid is converted into marine, nitrous, and vitriolic acids; whence gypſum, alum, ſulphur; into fluor-acid, whence fluor; into ſiliceous acid, whence flint, the ſand of the ſea, and other ſtrata of ſiliceous ſand and marl; ſome moraſſes ferment like new hay, and, ſubliming their phlogiſtic part, form coal-beds above and clay below, which are alſo produced by elutriation; ſhell-fiſh in ſome moraſſes, hence ſhells ſometimes found on coals and over iron-ſtone.

NOTE XVIII.....IRON

CALCIFORM ores; combuſtion of iron in vital air; ſteel from deprivation of vital air; welding; hardneſs; brittleneſs like Rupert's drops; ſpecific levity; hardneſs and brittleneſs compared; ſteel tempered by its colours; modern production of iron, manganeſe, calamy; ſeptaria of iron-ſtone ejected from volcanos; red-hot cannon balls.

NOTE XIX.....FLINT.

1. *Siliceous rocks* from moraſſes; their cements. 2. *Siliceous trees*; coloured by iron or manganeſe; Peak-diamonds; Briſtol-ſtones; flint in form of calcareous ſpar; has been fluid without much heat; obtained from powdered quartz and fluor-acid by Bergman and by Achard. 3. *Agates and onyxes* found in ſand-rocks; of vegetable origin; have been in complete fuſion; their concentric coloured circles not from ſuperinduction but from congelation; experiment of freezing a ſolution of blue vitriol; iron and manganeſe repelled in ſpheres as the nodule of flint cooled; circular ſtains of marl in ſalt-mines; ſome flint nodules reſemble knots of wood or roots. 4. *Sand of the ſea*; its acid from moraſſes; its baſe from ſhells. 5. *Chert or petroſilex* ſtratified in cooling; their colour and their acid from ſea-animals; Labradore-ſtone from mother-pearl. 6. *Flints in chalk-beds*; their form, colour, and acid, from the fleſh of ſea-animals; ſome are hollow and lined with cryſtals; contain iron; not produced by injection from without; coralloids converted to flint; French-millſtones; flints ſometimes found in ſolid ſtrata. 7. *Angles of ſand* deſtroyed by attrition and ſolution in ſteam; ſiliceous breccia cemented by ſolution in red-hot water. 8. *Baſaltes and granites* are antient lavas; baſaltes raiſed by its congelation not by ſubterraneous fire.

NOTE XX.....CLAY.

FIRE and water two great agents; ſtratification from precipitation; many ſtratified materials not ſoluble in water. 1. Stratification of lava from ſucceſſive accumulation. 2. Stratifications of limeſtone from the different periods of time in which the ſhells were

depofited. 3. Stratifications of coal, and clay, and fandftone, and iron-ores, not from currents of water, but from the production of morafs-beds at different periods of time; morafs-beds become ignited; their bitumen and fulphur is fublimed; the clay, lime, and iron remain; whence fand, marle, coal, white clay in valleys, and gravel-beds, and fome ochres, and fome calcareous depofitions owing to alluviation; clay from decompofed granite; from the lava of Vefuvius; from vitreous lavas.

Note XXI.....Enamels.

Rose-colour and purple from gold; precipitates of gold by alcaline falt preferable to thofe by tin; aurum fulminans long ground; tender colours from gold or iron not diffolved but fufpended in the glafs; cobalts; calces of cobalt and copper require a ftrong fire; Ka-o-lin and Pe-tun-tfe the fame as our own materials.

Note XXII.....Portland Vase.

Its figures do not allude to private hiftory; they reprefent a part of the Elufinian myfteries; marriage of Cupid and Pfyche; proceffion of torches; the figures in one compartment reprefent Mortal Life in the act of expiring, and Humankind attending to her with concern; Adam and Eve hyeroglyphic figures; Abel and Cain other hyeroglyphic figures; on the other compartment is reprefented Immortal Life, the Manes or Ghoft defcending into Elifium is led on by Divine Love, and received by Immortal Life, and conducted to Pluto; Tree of Life and Knowledge are emblematical; the figure at the bottom is of Atis, the firft great Hierophant, or teacher of myfteries.

Note XXIII.....Coal.

1. A fountain of foffile tar in Shropfhire; has been diftilled from the coal-beds beneath, and condenfed in the cavities of a fand-rock; the coal beneath is deprived of its bitumen in part; bitumen fublimed at Matlock into cavities lined with fpar. 2. Coal has been expofed to heat; woody fibres and vegetable feeds in coal at Bovey and Polefworth; upper part of coal-beds more bituminous at Beaudefert; thin ftratum of afphaltum near Caulk; upper part of coal-bed worfe at Alfreton; upper ftratum of no value at Widdrington; alum at Weft-Hallum; at Bilfton. 3. Coal at Coalbrooke-Dale has been immerfed in the fea, fhewn by fea-fhells; marks of violence in the colliery at Mendip and at Ticknal; Lead-ore and fpar in coal-beds; gravel over coal near Lichfield; Coal produced from moraffes fhewn by fern-leaves, and bog-fhells, and mufcle-fhells; by fome parts of coal being ftill woody; from Lock Neagh and Bovey, and the Temple of the devil; fixed alcali; oil.

Note XXIV.....Granite.

Granite the loweft ftratum of the earth yet known; porphory, trap, Moor-ftone, Whin-ftone, flate, bafaltes, all volcanic productions diffolved in red-hot water; volcanos in granite ftrata; differ from the heat of moraffes from fermentation; the

nucleus of the earth ejected from the ſun? was the ſun originally a planet? ſuppoſed ſection of the globe.

NOTE XXV.....EVAPORATION.

I. Solution of water in air; in the matter of heat; pulſe-glaſs. 2. Heat is the principal cauſe of evaporation; thermometer cooled by evaporation of ether; heat given from ſteam to the worm-tub; warmth accompanying rain. 3. Steam condenſed on the eduction of heat; moiſture on cold walls; ſouth-weſt and north-eaſt winds. 4. Solution of ſalt and of blue vitriol in the matter of heat. II. Other vapours may precipitate ſteam and form rain. 1. Cold the principal cauſe of devaporation; hence the ſteam diſſolved in heat is precipitated, but that diſſolved in air remains even in froſts; ſouth-weſt wind. 2. North-eaſt winds mixing with ſouth-weſt winds produce rain; becauſe the cold particles of air of the north-eaſt acquire ſome of the matter of heat from the ſouth-weſt winds. 3. Devaporation from mechanical expanſion of air, as in the receiver of an air-pump; ſummer-clouds appear and vaniſh; when the barometers ſink without change of wind the weather becomes colder. 4. Solution of water in electric fluid dubious. 5. Barometer ſinks from the leſſened gravity of the air, and from the rain having leſs preſſure as it falls; a mixture of a ſolution of water in calorique with an aerial ſolution of water is lighter than dry air; breath of animals in cold weather why condenſed into viſible vapour and diſſolved again.

NOTE XXVI.....SPRINGS.

LOWEST ſtrata of the earth appear on the higheſt hills; ſprings from dews ſliding between them; mountains are colder than plains; 1. from their being inſulated in the air; 2. from their enlarged ſurface; 3. from the rarety of the air it becomes a better conductor of heat; 4. by the air on mountains being mechanically rarefied as it aſcends; 5. gravitation of the matter of heat; 6. the daſhing of clouds againſt hills; of fogs againſt trees; ſprings ſtronger in hot days with cold nights; ſtreams from ſubterranean caverns; from beneath the ſnow on the Alps.

NOTE XXVII.....SHELL-FISH.

THE armour of the Echinus moveable; holds itſelf in ſtorms to ſtones by 1200 or 2000 ſtrings: Nautilus rows and ſails; renders its ſhell buoyant: Pinna and Cancer; Byſſus of the antients was the beard of the Pinna; as fine as the ſilk is ſpun by the ſilk-worm; gloves made of it; the beard of muſcles produces ſickneſs; Indian weed; tendons of rats tails.

NOTE XXVIII.....STURGEON.

STURGEON'S mouth like a purſe; without teeth; tendrils like worms hang before his lips, which entice ſmall fiſh and ſea-inſects miſtaking them for worms; his ſkin uſed for covering carriages; iſinglaſs made from it; caviare from the ſpawn.

Note XXIX.....Oil on Water.

Oil and water do not touch; a ſecond drop of oil will not diffuſe itſelf on the preceeding one; hence it ſtills the waves; divers for pearl carry oil in their mouths; oil on water produces priſmatic colours; oiled cork circulates on water; a phial of oil and water made to oſcillate.

Note XXX.....Ship-Worm.

The Teredo has calcareous jaws; a new enemy; they periſh when they meet together in their ligneous canals; United Provinces alarmed for the piles of the banks of Zeland; were deſtroyed by a ſevere winter.

Note XXXI.....Maelstrom.

A Whirlpool on the coaſt of Norway; paſſes through a ſubterraneous cavity; leſs violent when the tide is up; eddies become hollow in the middle; heavy bodies are thrown out by eddies; light ones retained; oil and water whirled in a phial; hurricanes explained.

Note XXXII.....Glaciers.

Snow in contact with the earth is in a ſtate of thaw; ice-houſes; rivers from beneath the ſnow; rime in ſpring vaniſhes by its contact with the earth; and ſnow by its evaporation and contact with the earth; moſs vegetates beneath the ſnow; and Alpine plants periſh at Upſal for want of ſnow.

Note XXXIII.....Winds.

Air is perpetually ſubject to increaſe and to diminution; Oxygene is perpetually produced from vegetables in the ſunſhine, and from clouds in the light, and from water; Azote is perpetually produced from animal and vegetable putrefaction, or combuſtion; from ſprings of water; volatile alcali; fixed alcali; ſea-water; they are both perpetually diminiſhed by their contact with the ſoil, producing nitre; Oxygene is diminiſhed in the production of all acids; Azote by the growth of animal bodies; charcoal in burning conſumes double its weight of pure air; every barrel of red-lead abſorbes 2000 cubic feet of vital air; air obtained from variety of ſubſtances by Dr. Prieſtley; Officina aeris in the polar circle, and at the Line. *Souh-weſt winds*; their weſterly direction from the leſs velocity of the earth's ſurface; the contrary in reſpect to north-eaſt winds; South-weſt winds conſiſt of regions of air from the ſouth; and north-eaſt winds of regions of air from the north; when the ſouth-weſt prevails for weeks and the barometer ſinks to 28, what becomes of above one fifteenth part of the atmoſphere; 1. It is not carried back by ſuperior currents; 2. Not from its loſs of moiſture; 3. Not carried over the pole; 4. Not owing to atmoſpheric tides or mountains; 5. It is abſorbed at the polar circle; hence ſouth-weſt winds and rain; ſouth-weſt ſometimes cold. *North-eaſt winds* conſiſt of air from the north; cold by the evaporation of ice; are dry winds; 1. Not ſup-

plied by ſuperior currents; 2. The whole atmoſphere increaſed in quantity by air ſet at liberty from its combinations in the polar circles. *South-eaſt winds* conſiſt of north winds driven back. *North-weſt winds* conſiſt of ſouth-weſt winds driven back; north-weſt winds of America bring froſt; owing to a vertical ſpiral eddy of air between the eaſtern coaſt and the Apalachian mountains; hence the greater cold of North America. *Trade-winds*; air over the Line always hotter than at the tropics; trade-winds gain their eaſterly direction from the greater velocity of the earth's ſurface at the line; not ſupplied by ſuperior currents; ſupplied by decompoſed water in the ſun's great light; 1. Becauſe there are no conſtant rains in the tract of the trade-winds; 2. Becauſe there is no condenſible vapour above three or four miles high at the line. *Monſoons and tornadoes*; ſome places at the tropic become warmer when the ſun is vertical than at the line; hence the air aſcends, ſupplied on one ſide by the north-eaſt winds, and on the other by the ſouth-weſt; whence an aſcending eddy or tornado, raiſing water from the ſea, or ſand from the deſert, and inceſſant rains; air diminiſhed to the northward produces ſouth-weſt winds; tornadoes from heavier air above ſinking through lighter air below, which riſes through a perforation; hence trees are thrown down in a narrow line of twenty or forty yards broad, the ſea riſes like a cone, with great rain and lightning. *Land and ſea breezes*; ſea leſs heated than land; tropical iſlands more heated in the day than the ſea, and are cooled more in the night. *Concluſion*; irregular winds from other cauſes; only two original winds north and ſouth; different ſounds of north-eaſt and ſouth-weſt winds; a Bear or Dragon in the arctic circle that ſwallows at times and diſembogues again above one fifteenth part of the atmoſphere; wind-inſtruments; recapitulation.

Note XXXIV.....Vegetable Perspiration.

Pure air from Dr. Prieſtley's vegetable matter, and from vegetable leaves, owing to decompoſition of water; the hydrogene retained by the vegetables; plants in the ſhade are *tanned* green by the ſun's light; animal ſkins are *tanned* yellow by the retention of hydrogene; much pure air from dew on a ſunny morning; bleaching why ſooner performed on cotton than linen; bees wax bleached; metals calcined by decompoſition of water; oil bleached in the light becomes yellow again in the dark; nitrous acid coloured by being expoſed to the ſun; vegetables perſpire more than animals, hence in the ſunſhine they purify air more by their perſpiration than they injure it by their reſpiration; they grow faſteſt in their ſleep.

Note XXXV.....Vegetable Placentation.

Buds the viviparous offspring of vegetables; placentation in bulbs and ſeeds; placentation of buds in the roots, hence the riſing of ſap in the ſpring, as in vines, birch, which ceaſes as ſoon as the leaves expand; production of the leaf of Horſe-cheſnut, and of its new bud; oil of vitriol on the bud of Mimoſa killed the leaf alſo; placentation ſhewn from the ſweetneſs of the ſap; no umbilical artery in vegetables.

Note XXXVI.....Vegetable Circulation.

Buds set in the ground will grow if prevented from bleeding to death by a cement; vegetables require no muscles of locomotion, no stomach or bowels, no general system of veins; they have, 1. Three systems of absorbent vessels; 2. Two pulmonary systems; 3. Arterial systems; 4. Glands; 5. Organs of reproduction; 6. muscles. I. Absorbent system evinced by experiments by coloured absorptions in fig-tree and picris; called air-vessels erroneously; spiral structure of absorbent vessels; retrograde motion of them like the throats of cows. II. Pulmonary arteries in the leaves, and pulmonary veins; no general system of veins shewn by experiment; no heart; the arteries act like the vena portarum of the liver; pulmonary system in the petals of flowers; circulation owing to living irritability; vegetable absorption more powerful than animal, as in vines; not by capillary attraction.

Note XXXVII.....Vegetable Respiration.

I. Leaves not perspiratory organs, nor excretory ones; lungs of animals. 1. Great surfaces of leaves. 2. Vegetable blood changes colour in the leaves; experiment with spurge; with picris. 3. Upper surface of the leaf only acts as a respiratory organ. 4. Upper surface repels moisture; leaves laid on water. 5. Leaves killed by oil like insects; muscles at the foot-stalks of leaves. 6. Use of light to vegetable leaves; experiments of Priestley, Ingenhouze, and Scheel. 7. Vegetable circulation similar to that of fish. II. Another pulmonary system belongs to flowers; colours of flowers. 1. Vascular structure of the corol. 2. Glands producing honey, wax, &c. perish with the corol. 3. Many flowers have no green leaves attending them, as Colchicum. 4. Corols not for the defence of the stamens. 5. Corol of Helleborus Niger changes to a calyx. 6. Green leaves not necessary to the fruit-bud; green leaves of Colchicum belong to the new bulb not to the flower. 7. Flower-bud after the corol falls is simply an uterus; mature flowers not injured by taking of the green leaves. 8. Inosculation of vegetable vessels.

Note XXXVIII.....Vegetable Impregnation.

Seeds in broom discovered twenty days before the flower opens; progress of the seed after impregnation; seeds exist before fecundation; analogy between seeds and eggs; progress of the egg within the hen; spawn of frogs and of fish; male Salamander; marine plants project a liquor not a powder; seminal fluid diluted with water, if a stimulus only? Male and female influence necessary in animals, insects, and vegetables, both in production of seeds and buds; does the embryon seed produce the surrounding fruit, like insects in gall-nuts?

NOTE XXXIX.....VEGETABLE GLANDULATION.

VEGETABLE glands cannot be injected with coloured fluids; essential oil; wax; honey; nectary, its complicate apparatus; exposes the honey to the air like the lacrymal gland; honey is nutritious; the male and female parts of flowers copulate and die like moths and butterflies, and are fed like them with honey; anthers supposed to become insects; depredation of the honey and wax injurious to plants; honey-dew; honey oxygenated by exposure to air; necessary for the production of sensibility; the provision for the embryon plant of honey, sugar, starch, &c. supplies food to numerous classes of animals; various vegetable secretions as gum tragacanth, camphor, elemi, anime, turpentine, balsam of Mecca, aloe, myrrh, elastic resin, manna, sugar, wax, tallow, and many other concrete juices; vegetable digestion; chemical production of sugar would multiply mankind; economy of nature.

THE END.

Errata in Part I.

Page 34. l. 354. for *the* read *her*.
37. l. 379. for *burſts* read *burſt*.
41. l. 423. for *wirh* read *with*.
58. At the end of the Argument, inſtead of "*Departure of the Gnomes*" pleaſe to add *Tranſmigration of matter*, 575. *Death and reſuſcitation of Adonis*, 585. *Departure of the Gnomes*, 611.

Page 76. inſtead of III. put 3.
80. inſtead of IV. put 4.
144. l. 376. for *ſhut* read *ſhuts*.
147. l. 423. for *ſinking* read *ſhrinking*.
170. l. 110. for *her* read *its*.
190. l. 359. for *decry'd* read *deſcry'd*.
204. l. 530. for *nectarous* read *nectareous*.

In the Additional Notes.

Page 44. l. 12. for *frigorific* read *frigoreſcent*.
45. l. 6. for *congelating* read *congealing*.

Page 46. l. 4. for *concholoide* read *conchoide*.
49. l. 20. for *word* read *world*.

DIRECTIONS TO THE BINDER.

Pleaſe to place the print of Flora attired by the Elements oppoſite to the Title-page.

Place all the four prints of the Portland Vaſe oppoſite to Page 88, in the following order:

I. The print of the whole Vaſe.
II. The firſt compartment of it.
III. The ſecond compartment of it.
IV. The bottom and handles.

Cypripedium fronting Page 202.
Erythrina fronting Page 205.
Section of the earth fronting Page 65 of the Additional Notes.

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